Reference # 2

MRI REPORT

Improvement of Specific Emission Factors (BACM Project No. 1)

Final Report

Prepared by
Midwest Research Institute
425 Volker Boulevard
Kansas City, Missouri 64110

South Coast AQMD Contract No. 95040
MRI Project No. 3855

March 29, 1996

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Executive Summary

This summary describes the improved emission factors that were developed in this study for construction activities and paved roads in western states. For construction activities, four levels of emission estimation are presented. The first level (area-based) may be directly substituted into any prior inventory that incorporated the original AP-42 construction emission factor. The other three levels offer increasing accuracy as compared to the area-based factor but require successively more detail on the types and intensities of construction activity in the inventory study area.

Emission Factors for Construction Activities

In addition to the area-based emission factor, the current version of AP-42 also includes a series of factors for "unit operations" that occur at construction sites. These operations include activities such as loading and unloading of earth and aggregate materials; land clearing and general vehicle traffic. The unit operation approach can be expected to provide a more accurate emission estimate than the area-based factor for a given site because site-specific information can be used. On the other hand, the unit operation approach cannot be directly applied to the large-scale emission inventories maintained by air regulatory agencies because of the intensive input information required. The project described in this report bridges the gap between the two approaches.

This report describes a series of emission inventories (based on the unit operation approach) prepared for seven construction projects that were visited during the study. The sites were located in four study areas: Las Vegas, Coachella Valley, South Coast, and the San Joaquin Valley.

For each of the construction sites visited, the emission inventory took into account the type and intensity of construction activities observed at the site during the morning (before lunch break) and afternoon. Inventories made use of the "unit operation" emission factors given in AP-42 Table 13.2.3-1 together with activity observations and other data collection activities.

The investigation results for each site are summarized in Table ES-1. The table presents the range, mean, and standard deviation of the estimated hourly PM_{10} emission rate for on-site construction activities. In addition, the mean hourly rate is divided by the area of the construction site to develop an overall area-based PM_{10} emission factor of the same sort as the original TSP AP-42 emission factor that has been used in inventories since 1975. Given the range in size and level of activity from one construction site to another, it is not surprising that the overall, area-based emission factors range over two orders of magnitude.

Table ES-1. Summary of Uncontrolled PM_{10} Emission Rates Estimated for the Construction Sites

Site	Estimated uncontrolled PM_{10} emission rate (lb/hr)		Overall uncontrolled PM_{10} emission factor	
	Range	Mean ± S.D.	(lb/acre-work hr)	(ton/acre-month)[a]
1.1	82 - 150	116 ± 28	0.39	0.032
1.2	67 - 161	133 ± 44	3.8	0.32
2.1	18 - 146	82 ± 73	0.95	0.080
2.2	0.68 - 0.81	0.74 ± 0.065	0.046	0.0039
3.1	300 - 494	393 ± 80	4.8	0.40
3.2	560 - 793	712 ± 104	5.1	0.43
5.2	82 - 228	164 ± 74	4.1	0.34
			Geometric mean: 1.3 x/÷ 5.9	Geometric mean: 0.11 x/÷ 5.9

[a] Based on 168 work-hours per month.

Note that in a 1990 study for South Coast Air Quality Management District (SCAQMD), Midwest Research Institute (MRI) recommended an adjusted version of the original factor to reflect PM_{10} (rather than TSP) emissions from construction sites. The revised value for PM_{10}—0.31 ton/acre-month—serves as the basis for comparisons in this study.

Table ES-1 shows that the geometric mean of the emission factors is 0.11 ton/acre-month. Substitution of this value for the original AP-42 emission factor represents the simplest revision that can be recommended based on the present study.

The revised overall factor (0.11 ton/acre-month) is roughly three times smaller than the previous value of 0.31 ton/acre-month. However, direct comparisons between the original and revised factors can be somewhat misleading for at least two reasons:

- First, about half of the surveyed sites yielded an overall factor **greater** than 0.31 ton/acre-month. These sites were associated with large-scale earthmoving operations and trucking of fill material. On the other hand, sites without large-scale cut/fill operations yielded area-based factors smaller than the 0.31 ton/acre-month value. To at least partially account for this variability, the sites with active large-scale earthmoving operations were considered separately to obtain worst-case overall factor of 0.42 ton/acre-month.

- Second, the original factor includes effects of at least two emission sources not included in the proposed overall factor of 0.11 ton/acre-month. Because the original factor was based on air quality monitoring over areas that were several square miles in extent, any localized wind erosion or trackout would affect the monitors and hence the resulting emission factor. It is not clear how much wind erosion or mud/dirt trackout occurred at the sites that were tested in developing the original AP-42 factor.

It is important to recognize that the emission inventories (and any emission factors based on these results) reference uncontrolled conditions, i.e., they do not account for any mitigative effects of watering or other dust controls. This is in keeping with the EPA's guidance that AP-42 emission factors should represent the uncontrolled state. Although almost all sites visited regularly watered travel routes, none of the water truck traffic nor any effect of the water on emissions was included in the inventories.

The value of 0.11 ton/acre-month represents a straightforward means of revising current inventories by direct substitution of one emission factor for another. However, direct substitution retains the same problems associated with the generality of the original AP-42 ("one size fits all") emission factor. For example, how well do the characteristics of the inventoried sites match the characteristics of construction sites in general? Do the inventoried sites contain a disproportionally large amount of earthmoving?

To account for differences in activity levels from one site to another, a second level of aggregation was undertaken to develop an improved emission factor. This approach recognized that operations related to off-highway and over-the-road vehicle movement of cut/fill and other materials typically accounted for more than half of emissions estimated for a site. Emissions from those activities were removed from the site totals. Remaining emissions were averaged and normalized by the site's area. The remaining emission estimates were deemed "general construction." The "general construction" emission factors exhibit far less variability than do overall factors, presumably because they isolate the effect of important source contributions.

This report also contains normalized truck and scraper factors that can be used to estimate emissions from earthmoving operations. Recognizing that end-users will not always have readily available information on numbers of tons and miles transported, a third level of aggregation yielded default factors for off-highway scrapers and over-the-road trucks hauling construction materials (e.g., fill, road base, etc.).

Table ES-2 summarizes the emission estimation methods recommended on the basis of the present study. As shown, four different levels are recommended. The first level represents direct substitution of the overall factors and represents an areawide average. Levels 2, 3, and 4 require that progressively more information be known about the site. The information needed to apply Levels 2 or 3 to areawide emission inventories could be developed by an agency through review of building or dust control permits, or through direct survey of construction contractors. Agencies would develop guidelines to estimate the amount of cut/fill for different classes (e.g., residential, commercial, institutional, etc.) of construction in much the same manner as they currently estimate area disturbed on the basis of a construction project's valuation. Level 4, on the other hand, requires detailed knowledge and probably represents a methodology that can only be used to generate site-specific rather than areawide emission estimates.

Table ES-2. Recommended Emission Factors

Basis for emission factor	Recommended PM_{10} construction emission factor
Level 1—Only area and duration known	**Apply** 0.11 ton/acre-month (average conditions) 0.42 ton/acre-month (worst-case conditions)
Level 2—Area and amount of earthmoving known	**Apply** 0.011 ton/acre-month for each month of construction activity **Plus** 0.059 ton/1,000 yard^3 of on-site cut/fill 0.22 ton/1,000 yard^3 of off-site cut/fill These values are based on an assumption that one scraper can move 70,000 yard^3 of earth in one month and 35,000 yard^3 of material can be moved by truck in one month. If the on-/off-site fraction is not known, assume 100% on-site.
Level 3—More detailed information available on duration of earthmoving and other material movement.	**Apply** 0.13 lb/acre-work hr **plus** 49 lb/scraper-hr for on-site haulage[a] 94 lb/hr for off-site haulage[b]
Level 4—Detailed information on number of units and travel distances available	**Apply** 0.13 lb/acre-work hr **plus** 0.21 lb/ton-mile for on-site haulage 0.62 lb/ton-mile for off-site haulage[b]

[a] If the number of scrapers in use is not known, a default value of 4 may be used. In addition, if the actual capacity of earthmoving units is known, values given in the body of the report should be used.
[b] Factor for use with over-the-road trucks. If "off-highway" trucks are used haulage should be considered "on-site."

Emission Factors for Public Paved Roads

Concurrent with the surveys of construction sites, a field sampling program was undertaken to determine spatially averaged values of paved road surface silt loading and total loading in the four study areas. The purpose of this testing was to determine how silt loadings in the study areas compare to the distributions given in AP-42.

The results obtained in this study support suspicions that the AP-42 public road silt-loading database represents roads with higher than normal surface loadings. Median silt-loading values measured in this study were roughly 5 to 10 times lower than in AP-42. In fact, some of the high-ADT roads produced silt loadings slightly lower than the AP-42 default value for limited access roads (i.e., 0.02 g/m^2). During this program, no strictly quantitative method was used to distinguish between "low" and "high" ADT roads. Instead, roads were classified on the basis of how they were depicted on city street maps or on functional classification maps provided by the study area liaison. In general, the high ADT roads would be classified as "arterials" on "major streets," while the low ADT roadways could be termed "collectors" or "local streets."

Table ES-3 summarizes the revised paved road emission factors recommended for general use. Alternately, this report contains the information needed so that member agencies may employ the individual silt-loading and mean vehicle data in the same manner that AP-42 encourages readers to use individual values presented in AP-42.

Table ES-3. Recommended Paved Road PM_{10} Emission Factors

	Emission factor (g/VMT)		
	High-ADT	Low-ADT	Average[a]
Average conditions[b]	0.37	1.3	0.81
Worst-case conditions[c]	0.64	3.9	2.1

[a] Based on 65% of high- and 35% of low-ADT sL value.
[b] Based on median value and 2.4 tons.
[c] Based on 90th percentile and 2.4 tons.

Section 1
Introduction

The U.S. Environmental Protection Agency's (EPA) reclassification of five areas in the southwestern United States from "moderate" to "serious" PM_{10} nonattainment represents a challenge to state and local air regulatory groups. Simply put, to effectively plan and design control programs that will bring an area into attainment, regulators require reasonably accurate emission inventories. However, compiling accurate PM_{10} inventories in the Southwest is an extremely difficult task for the following reasons:

- Unlike other areas in the United States, fugitive dust from nontraditional sources accounts for a far greater portion of PM_{10} emitted in the planning area. Here, "nontraditional" is used to describe emission sources that typically were not subject to stringent air regulations in the past. Industrial plants (such as manufacturers, quarries, etc.), which have long been subject to air permitting and emission inventorying activities, are examples of "traditional" sources. Although construction activities are issued building permits, the need to control emissions from construction operations has only recently been included by many agencies that use planning to achieve air quality goals. Construction thus represents a nontraditional source. "Nontraditional" also refers to **public** PM_{10} sources (such as reentrainment of material from paved streets) as well as activities (such as unpaved driveways or off-road recreational vehicles) of **individual citizens.**

- Nontraditional sources are geographically diverse throughout a planning area and can usually be considered "moving targets." In other words, beyond the fact that it is difficult to locate and inventory all important nontraditional sources at any one time, many sources may not be present 6 months later while new sources will have appeared.

- Nontraditional sources can often have interaction effects. For example, emissions from public streets are usually higher near construction sites, unpaved driveways, etc., because loose material is "tracked off" and deposited on the paved road surface. As another example, off-road vehicles make open areas more susceptible to wind erosion.

- Unlike factors for ducted sources, techniques to estimate fugitive dust emissions are of more recent vintage and the techniques continue to evolve. Furthermore, fugitive dust emission factors usually take the form of predictive equations. Thus, to develop an accurate emission inventory, one must have confidence in the values input to each equation as well as appropriate measures of source activity.

Federal, state, and local regulators are well aware of deficiencies in currently available fugitive dust inventories. Even though the EPA recently completed updates to its emission factor handbook ("AP-42"),[1] there are still limitations in directly incorporating the revised factors into existing emission inventories. To address these problems, the BACM (best available control measure) Working Group has initiated several research studies. MRI performed one of these studies to improve certain emission factors based on field sampling, data collection, and analysis, as described in this report. Specifically, the objectives of the subject study are to:

1. **Recommend improved emission factors for use in estimating paved road dust emissions (on both an annual and 24-hr basis) for public roadways within each of the four study areas.**[a] As discussed in Sections 3 and 4, the plan has been designed to allow one not only (a) to distinguish between different functional classes of roadways but also (b) to further differentiate between the same class of roads in areas with different land use patterns.

2. **Recommend methods to estimate emissions (on both a 24-hr and annual basis) from construction activities within the four study areas.** As discussed in Sections 3 and 4, the plan has been designed to permit one not only (a) to develop areawide inventories based on summary types of information, but also (b) to prepare site-specific inventories for individual construction sites so that effective dust control plans can be developed for the sites.

The remainder of this report is structured as follows. Section 2 briefly summarizes background information on emission factor methodologies for paved roads and construction activities as well as limitations on their use. Section 3 describes the field test sites visited during the project and the field activities conducted at each site. Section 4 discusses how the field data were used to refine emission factor methodologies for the study areas. Section 5 summarizes the conclusions and recommendations, and Section 6 contains the references.

[a] In this plan, the term "study area" is used to refer to any of the four geographical areas in which field measurements will be made. The four areas are Las Vegas Valley, San Joaquin Valley, South Coast Air Basin, and Coachella Valley.

Section 2
Background

This section first discusses what methods are available for estimating emissions from paved roads and construction activities and then describes the underlying basis for each factor. The section also describes limitations of the different methodologies and what sort of refinements are necessary to improve the overall accuracy of emission inventories.

It is important that the reader keep several points in mind throughout the report. First, emission factors can serve several purposes. For example, one can produce estimates of either (a) areawide average emissions from a broad class of activity, or (b) emissions from a specific activity at an individual site, over a clearly defined time period. Each type of estimate serves a useful purpose, and any improved methodology should be capable of providing either. In other words, the study plan must be designed such that the resulting emission factors provide flexibility and can accommodate a variety of spatially and temporally resolved input parameters.

Also, emission factors generally are best suited to reflect average and relatively long-term conditions. In other words, an estimate for total emissions from a number of sources over a period of time is usually far more accurate than is an estimate for a single source condition at a specific time. For example, the paved and unpaved road emission factor equations in AP-42[1] reference combined emissions from all vehicles traveling a road. That is to say, one should not consider individual vehicles or vehicle classes and then attempt to combine separate emission estimates. This poses little problem in preparing emission inventories because source combinations are of primary interest.

Finally, it is important to recognize the similarities and differences between open dust sources at construction sites and those in other industries. For example, earthmoving and trenching in construction are comparable to materials handling operations used in mining and aggregate processing. Earthmoving and mining use similar types[2] of equipment to remove, transport, and reclaim materials. Like many other industries, construction also relies on truck deliveries of materials. These similarities justify use of the emission factors developed for the other industries.

Of course, the most important distinction to be drawn regarding construction involves its time duration. Unlike other industries, there usually is no "steady-state" or annual average condition. Whereas general mining activities can be expected to occur at least two-thirds of the year in most locations, earthmoving at a construction site may be completed within a one- or two-week period.

In practical terms, this means that it can be quite difficult to plan field activities for a construction site based on the results of a previous visit to the site. There is no "next year" that one can presume to be similar to years past.

2.1 Emission Estimates for Construction Activities

In 1993, EPA updated[3] fugitive dust emission factors contained in *Compilation of Air Pollutant Emission Factors* (AP-42).[1] The update specifically focused on problems that had been noted about factors for construction activities and paved roads.

The section on construction had not been revised to any substantive extent since its incorporation into AP-42 in 1975. The original section provided a single TSP emission factor to be used for a construction operation from start to end:

$$E = 1.2 \text{ ton/acre-month of activity}$$

where E represents TSP emissions.[b] The update found that, although the existing factor may have been useful for providing conservatively high emission estimates for broad geographic areas of interest, it cannot either (a) provide reliable estimates for a specific site or (b) subdivide construction source contributions for control planning purposes.

The updated AP-42 section includes emission estimates based on a unit operation approach. Under this approach, construction activities are broken down into generic operations, such as truck travel over paved or unpaved surfaces, site preparation by scrapers and graders, or the handling of aggregate material, and emission factors in other sections of AP-42 are recommended to develop estimates. Table 1 reproduces the new guidance on estimating emissions at construction sites.

The updated methodology offers improved emission estimates for a specific site. However, the new approach cannot be directly incorporated into current inventories that use the older factor based on disturbed surface area. The new approach requires more types of information and a higher degree of resolution.

To develop a means that Working Group members can use to develop areawide inventories, a series of field measurement activities (surface and activity characterization) were conducted so that a "mini-inventory" of PM_{10} emissions at each construction site was performed. Section 3 discusses how the field activities were conducted, and Section 4 describes how that information was used to develop an improved methodology.

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[b] Note that MRI recommended a revised factor of 0.31 ton/acre-month for use by the SCAQMD in a 1990 review.[4]

Table 1. Recommended Emission Factors for Construction Operations

Construction phase	Dust generating activities	Recommended emission factor	Comments
I. DEMOLITION AND DEBRIS REMOVAL	1. Demolition of buildings or other (natural) obstacles such as trees, boulders, etc.		
	1a. Mechanical dismemberment ("headache ball") of existing structures	NA	
	1b. Implosion of existing structures	NA	
	1c. Drilling and blasting of soil	Drilling factor (1.3 lb/hole) in Table 11.24-4 Blasting factor NA	Blasting factor in Table 11.24-1,-2 not considered appropriate for general construction activities
	1d. General land clearing	Dozer equation (overburden) in AP-42 Section for Western Surface Coal Mining (old Table 8.24-1, -2) $e = 0.75\ (s)^{1.5} / (M)^{1.4}$ where e = PM10 emission rate (lb/hr) s = surface silt content (%) M = surface moisture content (%)	
	2. Loading of debris into trucks	Material handling factor in Section 13.2.2 $e = 0.0011\ (U/5)^{1.3} / (M/2)^{1.4}$ where e = PM10 emission factor (lb/ton) U = mean wind speed (mph) M = material moisture content (%)	
	3. Truck transport of debris	Unpaved road emission factor in Section 13.2.1, $e = 2.1\ (s/12)\ (S/30)\ (W/3)^{0.7}\ (w/4)^{0.5}$ where e = PM10 emission factor (lb/vmt) s = surface material silt content (%) S = mean vehicle speed (mph) W = mean vehicle weight (tons) w = mean number of wheels per vehicle or Paved road emission factor in Section 13.2.4 $e = 0.016\ (sL/2)^{0.65}\ (W/3)^{1.5}$ where e = PM10 emission factor (lb/vmt) sL = silt loading (g/m^2) W = mean vehicle weight (tons)	

Table 1 (Continued)

Construction phase	Dust generating activities	Recommended emission factor	Comments
	4. Truck unloading of debris	Material handling factor in Section 13.2.2 $e = 0.0011 (U/5)^{1.3} / (M/2)^{1.4}$ where e = PM10 emission factor (lb/ton) U = mean wind speed (mph) M = material moisture content (%)	May occur off-site
II. SITE PREPARATION (EARTH MOVING)	1. Bulldozing	$e = 0.75 (s)^{1.5} / (M)^{1.4}$ where e = PM10 emission rate (lb/hr) s = surface silt content (%) M = surface moisture content (%)	
	2. Scrapers unloading topsoil	Scraper unloading factor 0.04 lb/ton in old Table 8.24-4	
	3. Scrapers in travel	Scraper (travel mode) expression in old Table 8.24-1, -2 $e = 0.0000037 (s)^{1.4} (W)^{2.5}$ where e = PM10 emission factor (lb/vmt) s = surface material silt content (%) W = mean vehicle weight (tons)	
	4. Scrapers removing topsoil	5.7 kg/VKT (20.2 lb/VMT)	
	5. Loading of excavated material into trucks	Material handling factor in Section 13.2.2 $e = 0.0011 (U/5)^{1.3} / (M/2)^{1.4}$ where e = PM10 emission factor (lb/ton) U = mean wind speed (mph) M = material moisture content (%)	
	6. Truck dumping of fill material, road base, or other materials	Material handling factor in Section 13.2.2 $e = 0.0011 (U/5)^{1.3} / (M/2)^{1.4}$ where e = PM10 emission factor (lb/ton) U = mean wind speed (mph) M = material moisture content (%)	May occur off-site
	7. Compacting	Dozer equation in old Table 8.24-1, -2 $e = 0.75 (s)^{1.5} / (M)^{1.4}$ where e = PM10 emission rate (lb/hr) s = surface silt content (%) M = surface moisture content (%)	Emission factor downgraded because of differences in operating equipment

Table 1 (Continued)

Construction phase	Dust generating activities	Recommended emission factor	Comments
	8. Motor grading	Grading equation in Table 8.24-1, -2 $e = 0.031\ (S)^{2.0}$ where e = PM10 emission factor (lb/vmt) S = mean vehicle speed (mph)	
III. GENERAL CONSTRUCTION	1. Vehicular traffic	Unpaved road emission factor in Section 13.2.1. $e = 2.1\ (s/12)\ (S/30)\ (W/3)^{0.7}\ (w/4)^{0.5}$ where e = PM10 emission factor (lb/vmt) s = surface material silt content (%) S = mean vehicle speed (mph) W = mean vehicle weight (tons) w = mean number of wheels per vehicle or, Paved road emission factor in Section 13.2.4 $e = 0.016\ (sL/2)^{0.65}\ (W/3)^{1.5}$ where e = PM10 emission factor (lb/vmt) sL = silt loading (g/m²) W = mean vehicle weight (tons)	
	2. Portable plants		
	2a. Crushing	Factors for similar material/operations in Section 11 (old Section 8) of AP-42	
	2b. Screening	Factors for similar material/operations in Section 11 (old Section 8) of AP-42	
	2c. Material transfers	Material handling factor in Section 13.2.2 $e = 0.0011\ (U/5)^{1.3}\ /\ (M/2)^{1.4}$ where e = PM10 emission factor (lb/ton) U = mean wind speed (mph) M = material moisture content (%)	
	3. Other operations	Factors for similar material/operations in Section 11 (old Section 8) of AP-42	

The study plan also made provision for focused emission testing at construction sites, because the emission measurement database for construction operations was extremely limited.[3] Although AP-42 has included an entry for construction-related dust emissions for almost 20 years, there had been little emission characterization performed that was directly applicable to construction. As indicated in Table 1, even the revised AP-42 Section 13.2 (formerly Section 11.2) borrows heavily from tests in the mining industries as well as the so-called "generic" fugitive dust factors. Although mining industry factors have been routinely applied to construction sites over the years, there have been no independent data against which the accuracy of the estimates can be assessed. It is generally unknown how accurately those factors predict emissions from construction sites. For example, many construction sites contain temporary, unimproved travel routes. At present, one cannot confidently answer the question: How well does the unpaved emission factor equation—which is based on field tests conducted on permanent roads—estimate emissions from the unimproved routes? Section 3.1 also describes how the limited-scale emission testing was conducted to address this shortcoming in the available database.

2.2 Paved Road Emission Estimates

The AP-42 update[3] also addressed shortcomings in the methods used to estimate emissions from paved roads. For over 10 years, AP-42 presented three sets of paved road emission factor models, and it was sometimes difficult to select the set that was appropriate for a particular application. During that period, distinctions between "urban" and "industrial" paved roads became blurred, and it was unknown how well the "urban" emission factors performed for cases of increased surface loading on public roads (such as after application of antiskid materials, within areas of track-out from construction, or after the accumulation of "blowsand").

The recent AP-42 update addressed these issues by combining the old "urban" and "industrial" emission factor databases and supplemented the combined database with additional tests. The end result consolidated two older AP-42 sections into a single section containing an emission factor in the form:

$$e = k\,(sL/2)^{0.65}\,(W/3)^{1.5}$$

where:
- e = emission factor in g/vehicle-mile traveled (g/VMT) for a particular particle size range (see k below)
- sL = silt loading (amount of loose, dry material smaller than 200 mesh present on the road surface area) in g/m^2
- W = mean weight in tons of vehicles traveling the road
- k = base emission factor (g/VMT) for particle size range as given below

Particle size range	k (g/VMT)
$PM_{2.5}$	3.3
PM_{10}	7.3
PM_{15}	9.0
PM_{30}	38

In contrast with the alternate AP-42 methodology for construction, the revised paved road equation can be fairly readily substituted into existing emission inventories. There remains some question about what silt-loading values are appropriate for public roads. Although AP-42 stresses the need to collect site-specific silt-loading ("sL") data, the new section assembled a public paved road sL database for possible use when site-specific information is not available.

The paved road sL database is limited in its usefulness in developing improved methodologies for the present study for various reasons:

- Almost two-thirds of the available data were collected in Montana, and only data collected in Montana provide information on the seasonal variation of sL.
- There has been little uniformity in either the sampling/analysis methods used to determine sL values or in schemes used to report roadway classifications.
- Examination of the database did not reveal any meaningful relationship between silt loading and other variables (such as average daily traffic [ADT], road class, etc.).
- It is suspected that the sL database is somewhat skewed toward high values. This is because the majority of measurements were collected during the first calendar half (which was found to have substantially higher values than the second half) and because of anecdotal information that at least some of the sampling programs focused on suspected trouble spots that were heavily loaded (such as after snow/ice storms, near construction sites, etc.).

Several sL sampling programs have been undertaken since the time of the AP-42 update. One study centered on the effectiveness of controls for mud and dirt trackout from construction sites.[5] The Idaho Department of Environmental Quality measured road loadings during the 1993 winter season in Pocatello. Washoe County, Nevada, is currently conducting a year-long study that will better define temporal variations. Although all provide useful information, none remove the limitations noted above.

The field program discussed in Section 3.2 was conducted to develop site-specific sL data for the study areas of interest. The study plan provided for collection of spatially averaged sL data for (a) different roadway classifications and (b) under "normal" and "elevated" conditions.

Section 3
Field Sampling and Data Collection Activities

This section discusses the field measurement and other data collection activities that were undertaken during the program.

3.1 Construction Sites

Two types of field activities were conducted at the selected construction sites. The first dealt with a demonstration case study that was conducted for each site. MRI collected site-specific aggregate material samples and monitored activity at each site over a period of 2 or 3 days. This information was used in conjunction with the factors in Table 1 to generate an **emission inventory of major PM_{10} dust sources at the time of the visit.** The inventories, in turn, were used to develop revised estimation methods (see Section 4.1).

The second type of field activity concerned limited **emission testing of certain PM_{10} sources** at construction sites. As noted in Section 2.1, the measurement database directly applicable to the construction emission sources is extremely limited. Testing conducted in this program provided independent data against which the accuracy of available emission factors may be assessed.

3.1.1 Description of Construction Test Sites

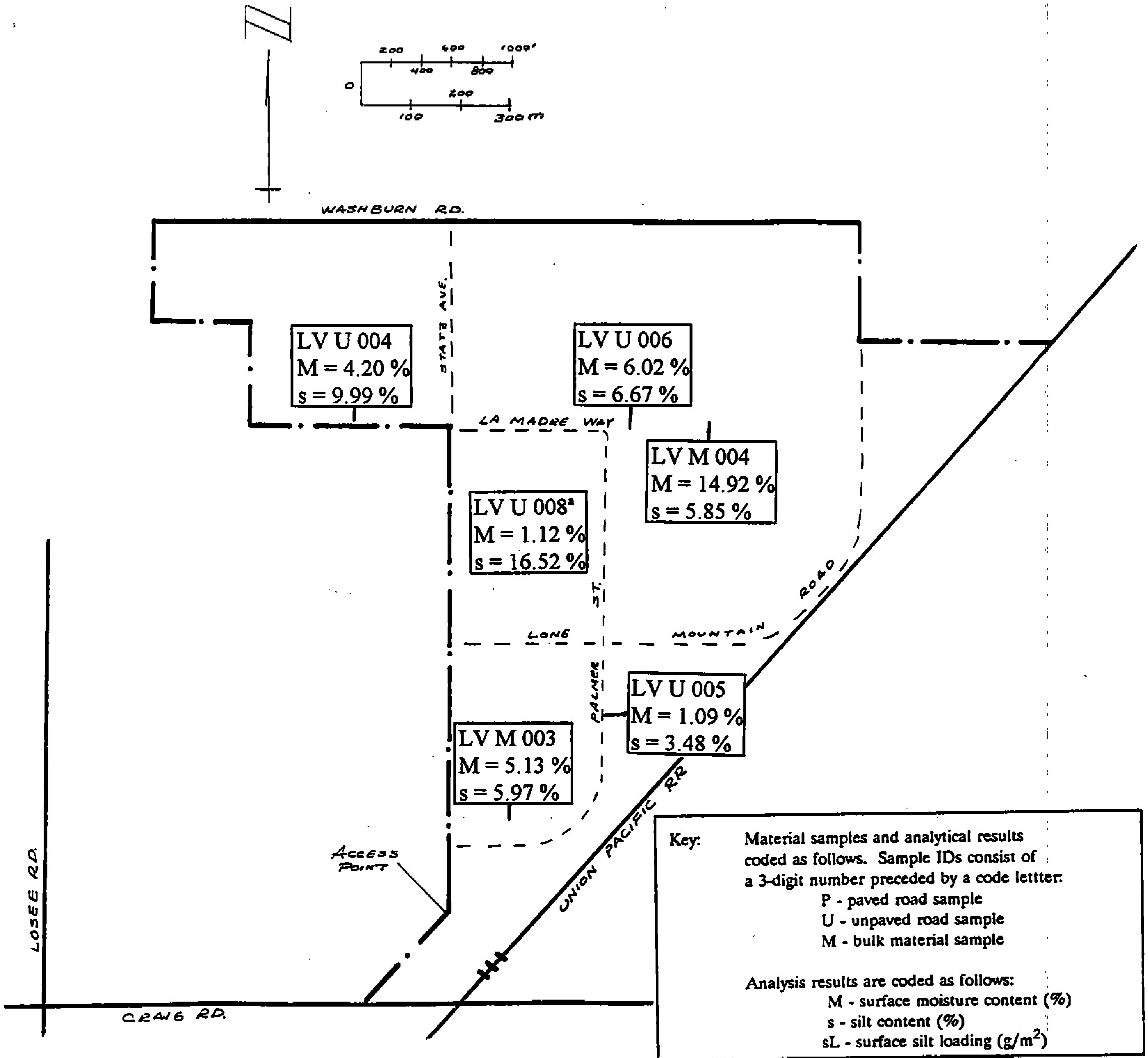
During the period of April 3 through 12, 1995, MRI visited candidate construction test sites in the four study areas. Sites had been identified by a Working Group liaison for the study area. From the candidates, MRI selected sites suitable for both field objectives (i.e., inventory and source testing). Table 2 presents the construction sites visited and describes what activities were present during the site visit and what activities were projected for the field sampling visit. MRI returned to the sites to perform field sampling activities during the period between June 19 and July 18, 1995.

As would be reasonably expected, some anticipated construction activities were not present when MRI returned to the sites in June and July. As a result, modifications to the sampling plans were sometimes necessary. The following paragraphs describe the sites selected as well as the construction activities that were in progress when MRI returned for sampling.[6]

Based on information learned during the April visits, three test sites were selected in the Las Vegas area. The first site selected (Site 1.1) was the Golden Triangle industrial park (Figure 1) being developed in North Las Vegas. Most large-scale

Table 2. Surveyed Construction Sites

Study area	Site	Type of construction	Construction activity levels: Observed during the April site survey	Projected to be present during June/July	Observed during June/July
Las Vegas	1.1	Industrial	Trenching and pipelaying, limited earthmoving	Construction of storm channel with concrete deliveries, other concrete work (e.g., sidewalks, etc.), road paving, trenching	Moderate activity including trenching, limited earthmoving, prepaving activities
	1.2	Residential	Scraper excavation in Unit 1, no activity in Units 2 or 3	General construction (pads, framing, etc.)	Moderate activity (trenching) in Unit 1
				Long haul of cut material from Unit 2 to Unit 3	Heavy activity (short-distance earthmoving, drilling/blasting, compaction) in Unit 2
	1.3	Residential	Construction not begun during April	Trenching, paving	None (trencher broken down during visit)
Coachella Valley	2.1	Residential	Construction not begun during April	Grading and paving of roads in Tract 27365 to start in mid-June	Moderate (trenching, prepaving) to heavy (trucking of road base)
	2.2	Residential	Trenching, road grading	General construction, with some trenching remaining. Chance of earthmoving	Low to moderate activity, including framing and landscaping
South Coast	3.1	Residential	Heavy earthmoving by scrapers	Heavy earthmoving with some long haul of cut material	Heavy activity (cut/fill with some limited stockpiling)
	3.2	Residential	Heavy earthmoving by scrapers (observed from off-site location)	Heavy earthmoving	Heavy earthmoving
San Joaquin Valley	5.2	Commercial	Site was not visited prior to sampling trip	Site was not visited prior to sampling trip	Moderate (trenching) to heavy activity (trucking of fill material)



[a] Taken from travel areas throughout site.

Figure 1. Site 1.1

earthmoving had been completed by the time of the July visits. A variety of activities were observed during the July return visit, including:

- trenching for sewers/utilities
- stockpiling of road base and other pre-paving operations
- scraper movement of spoils

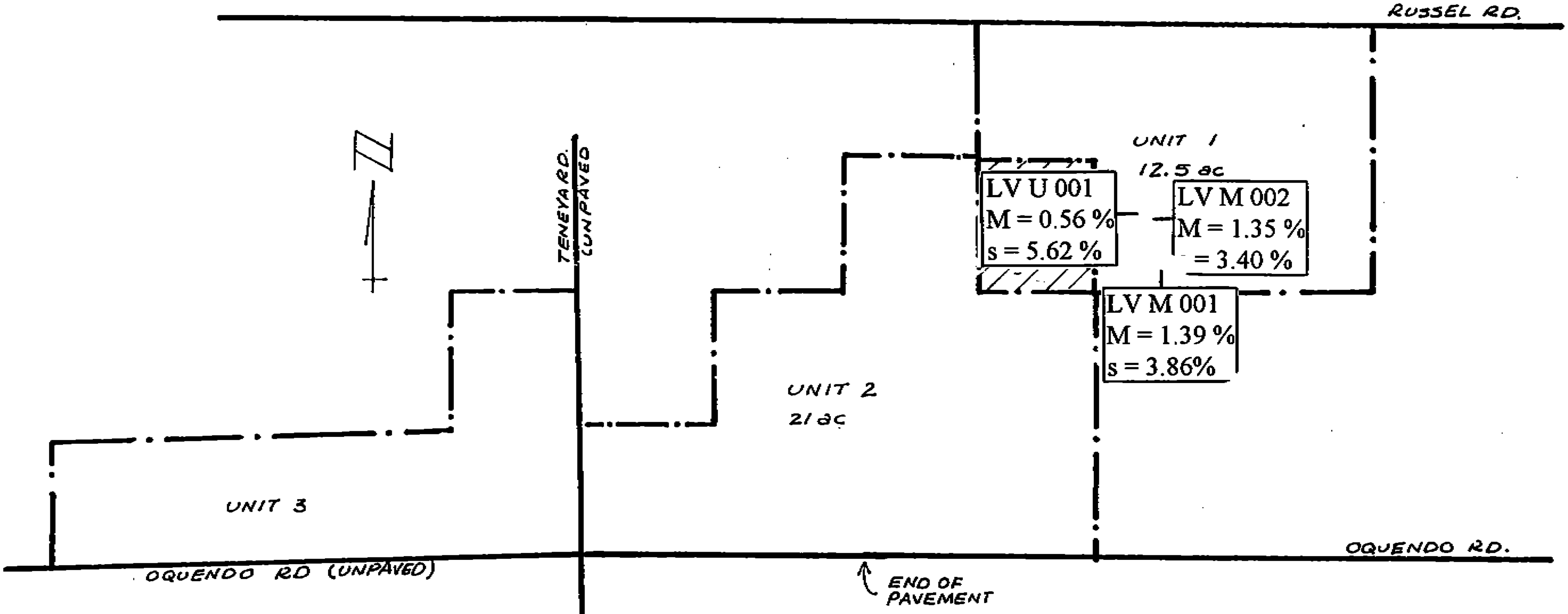
Site 1.2 was a residential construction site (Figure 2) in the southwestern part of metropolitan Las Vegas. The site was being developed near Russell and Rainbow Roads by Perma-Bilt Homes. Construction was planned for different phases, and Units 1, 2, and 3 were scheduled to be active during the summer of 1995. At the time of the April site surveys, it was expected that substantial earthmoving operations would occur during June with 80,000 cubic yards (cy) of material being moved from Unit 2 to Unit 3. Prior to arriving in June, however, MRI was informed that the long-haul movement was largely completed. During the return visit, MRI found mostly trenching activities in Unit 1 and fairly short-haul cut/fill operations in Unit 2.

The third site selected—Site 1.3—was another Perma-Bilt subdivision located near Maryland and Pebble roads in the southeastern portion of Las Vegas metropolitan area. In April, it was expected that grading activities would be completed before the return visit and that July activities would consist of trenching and general construction. During the return visit in July, however, no construction activity was present at this site because of equipment repairs.

Two residential sites were selected in the Coachella Valley. The first—Site 2.1—consisted of the Del Webb Sun City phased single- and multiple-family residential development (Figure 3) in Bermuda Dunes. In the northern tracts, houses were being "spot built" in areas with paved roads and utilities were already completed. The major construction activity anticipated during the April site surveys involved utility trenching and paving in Tract 27365, and blading of roads was scheduled to begin in mid-June.

Start-up of the Tract 17365 activities was delayed, however, until the second week of July. As a result, when MRI arrived at Site 2.1, the road base material had been delivered to Tract 27365. However, base material was delivered to an area farther to the north. This activity was observed and emissions estimated. Even though the activity occurred to the north, the estimated emissions were ascribed to the inventory for Tract 27365 to partially account for the importation of road base material that had occurred a few days earlier.

Site 2.2 in the Coachella Valley involved residential construction (Figure 4) in La Quinta. At this site near Miles Avenue and Dune Palms Road, Century Homes was building two "product lines" of homes. Construction was progressing from the corners toward the middle of the site.



Key: Material samples and analytical results coded as follows. Sample IDs consist of a 3-digit number preceded by a code lettter:

P - paved road sample
U - unpaved road sample
M - bulk material sample

Analysis results are coded as follows:

M - surface moisture content (%)
s - silt content (%)
sL - surface silt loading (g/m^2)

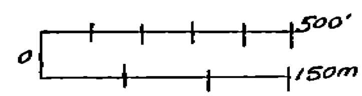


Figure 2. Site 1.2

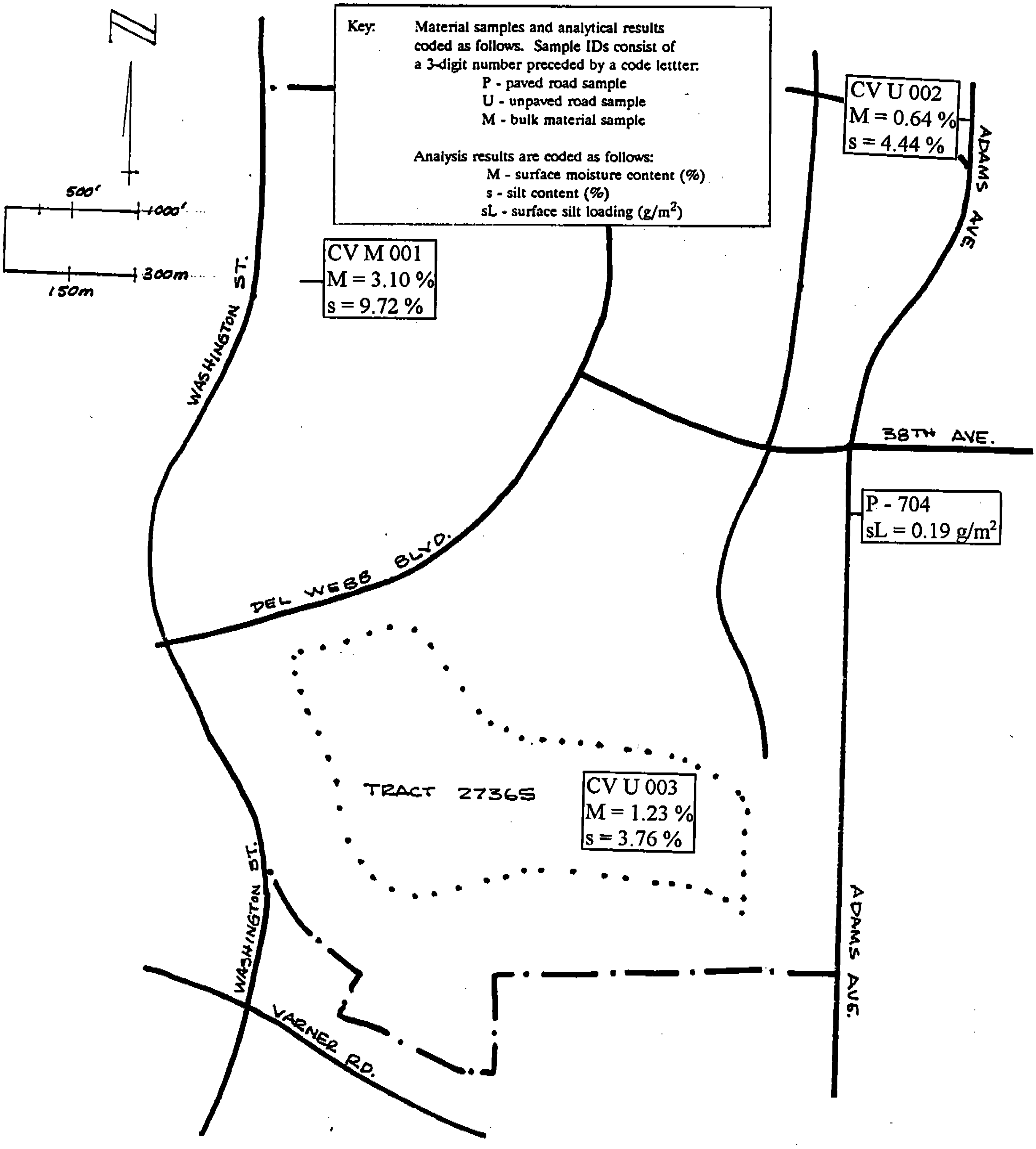


Figure 3. Site 2.1

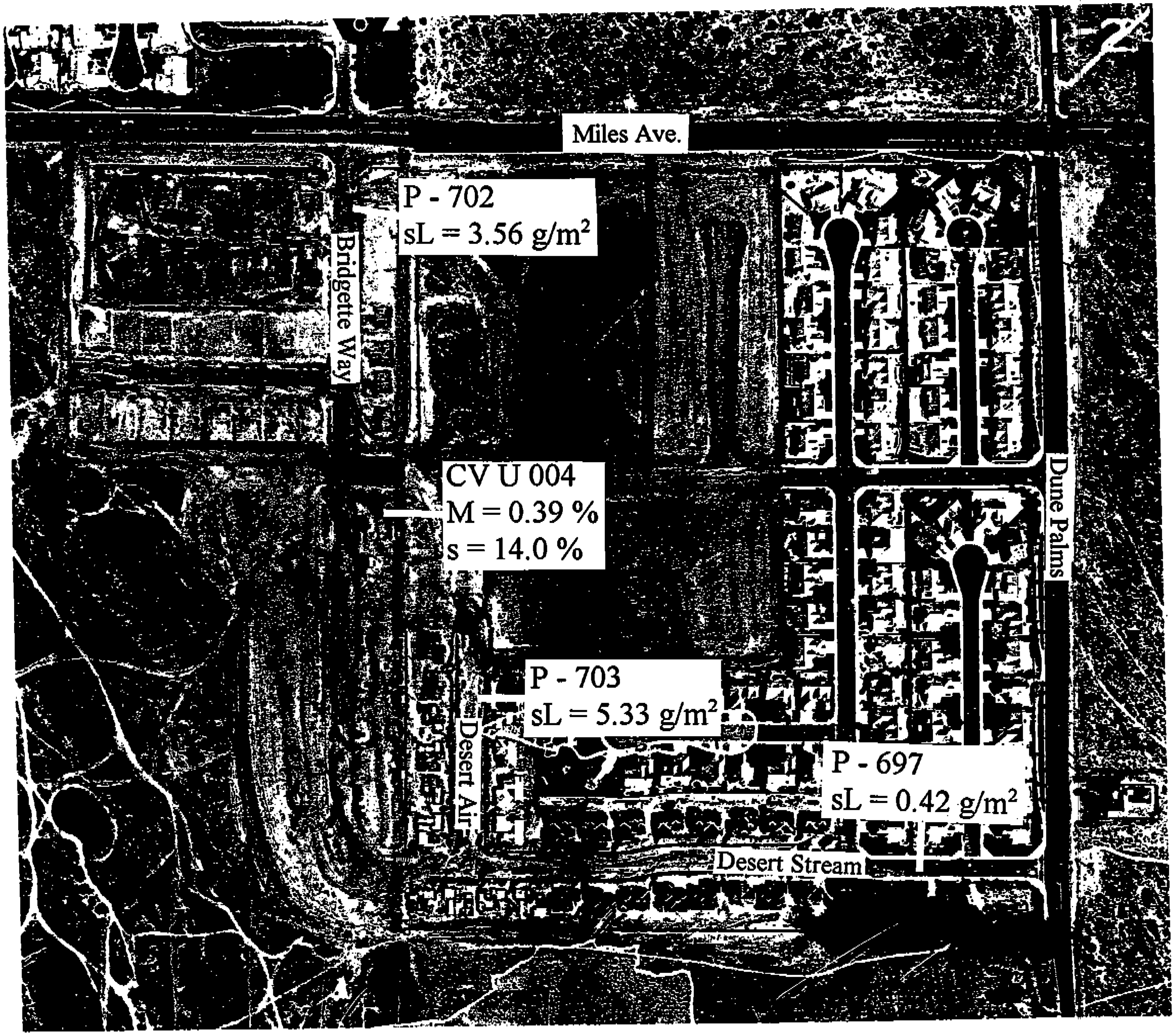


Figure 4. Site 2.2

Key:	Material samples and analytical results coded as follows. Sample IDs consist of a 3-digit number preceded by a code lettter: P - paved road sample U - unpaved road sample M - bulk material sample Analysis results are coded as follows: M - surface moisture content (%) s - silt content (%) sL - surface silt loading (g/m^2)

During the site survey, it was expected that trenching for utilities and flatwork/framing/finishing would occur during June and July, although some earthmoving (approximately 50,000 cy) might occur. During the return visit in July, only limited framing/finishing work was in progress.

Two large-scale earthmoving projects were selected based on the April survey visit to the South Coast area. Both projects were operated by SUKUT Construction. Site 3.1 concerned residential development in Newport Beach. This site involved cut/fill operations on a hillside to provide more ocean view lots. The project (Figure 5) involved the movement of 1,500,000 cy and was expected to run through June 1995. By the return visit in late June, most long routes had been completed although eight scrapers were still in daily cut/fill use. The other major activity observed was the construction of Loffel retaining walls along the eastern property line.

Site 3.2 (Figure 6) was another residential development ("Wishbone Hill"), located approximately 1 mile down the coast from Site 3.1. Earthmoving for this project also was expected to extend through June 1995. The site was unavailable for visiting during the April 1995 trip. At the time of the return visit in late June, eight scrapers were in daily use.

No sites were identified during the April visit to Bakersfield. During that visit, representatives of both the San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD) and MRI met with Building Industry Association (BIA) personnel to discuss study objectives and desirable attributes of candidate sites. Attempts failed to locate suitable sites in the Bakersfield area. However, SJVUAPCD personnel identified two candidate sites in the Fresno area. Arrangements were made to visit these sites in late July and early August to conduct the demonstration studies.

Site 5.1 involved construction of Valley Children's Hospital in Madera County. Activities observed during the July 31 visit included scraper excavation for foundations and trenching for utilities. Because of difficulties in obtaining corporate approval, full access to the site was not possible and no demonstration studies could be conducted.

Site 5.2 (Figure 7) pertained to a commercial development (Market Place at River Park) in northern Fresno. Construction activities observed included scraper cut/fill, trenching for sewer/utility, and importation of fill material.

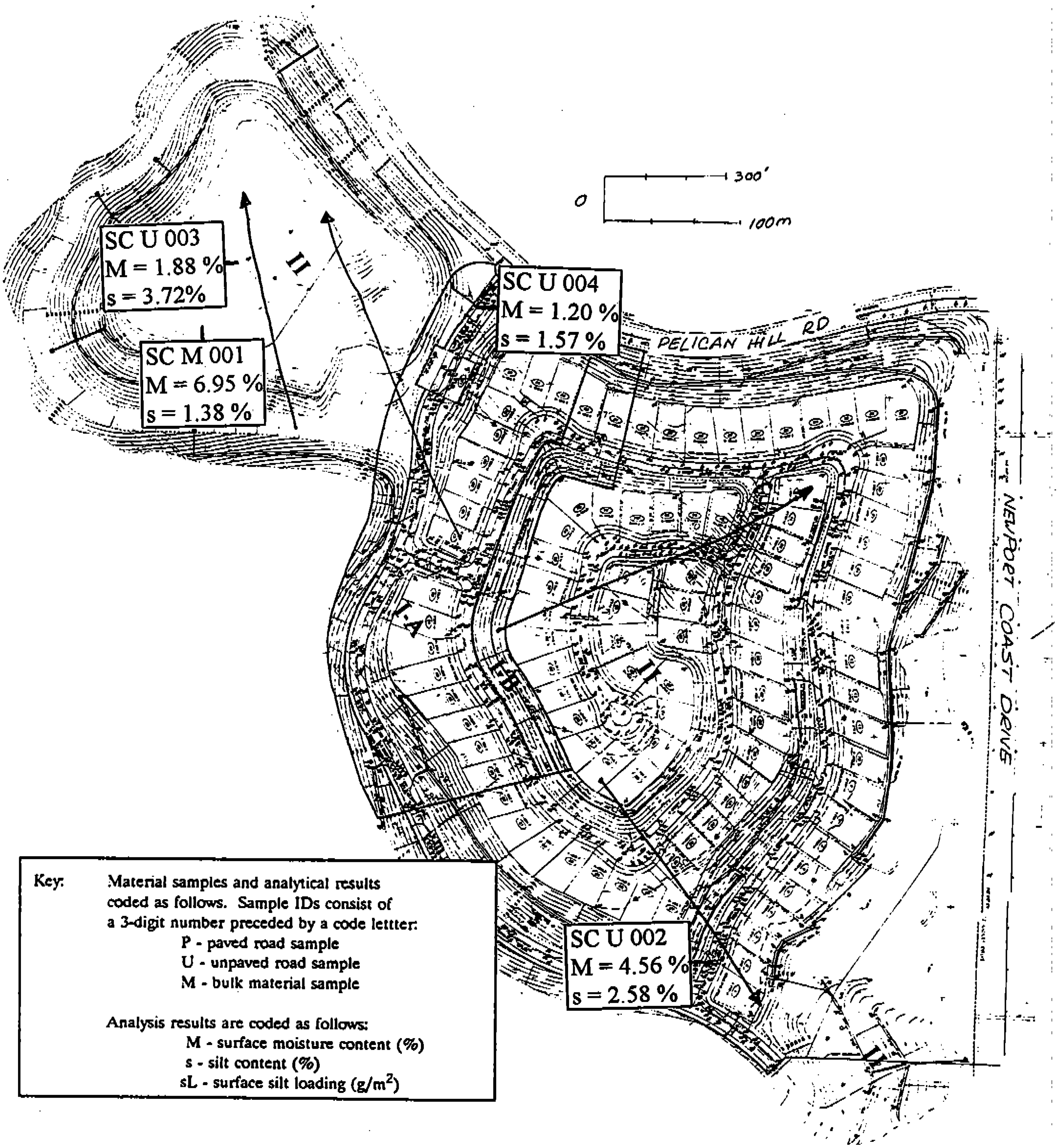


Figure 5. Site 3.1

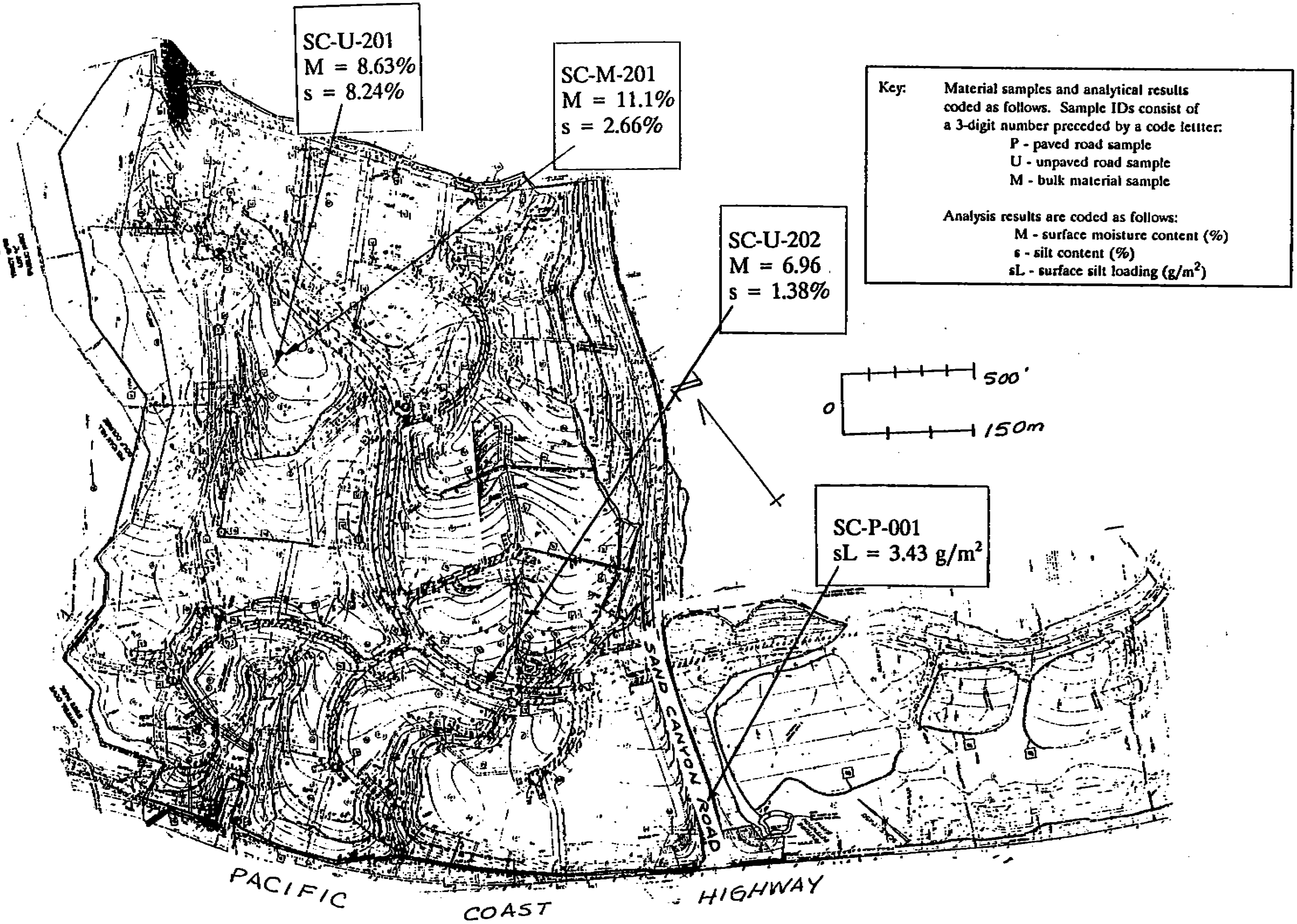


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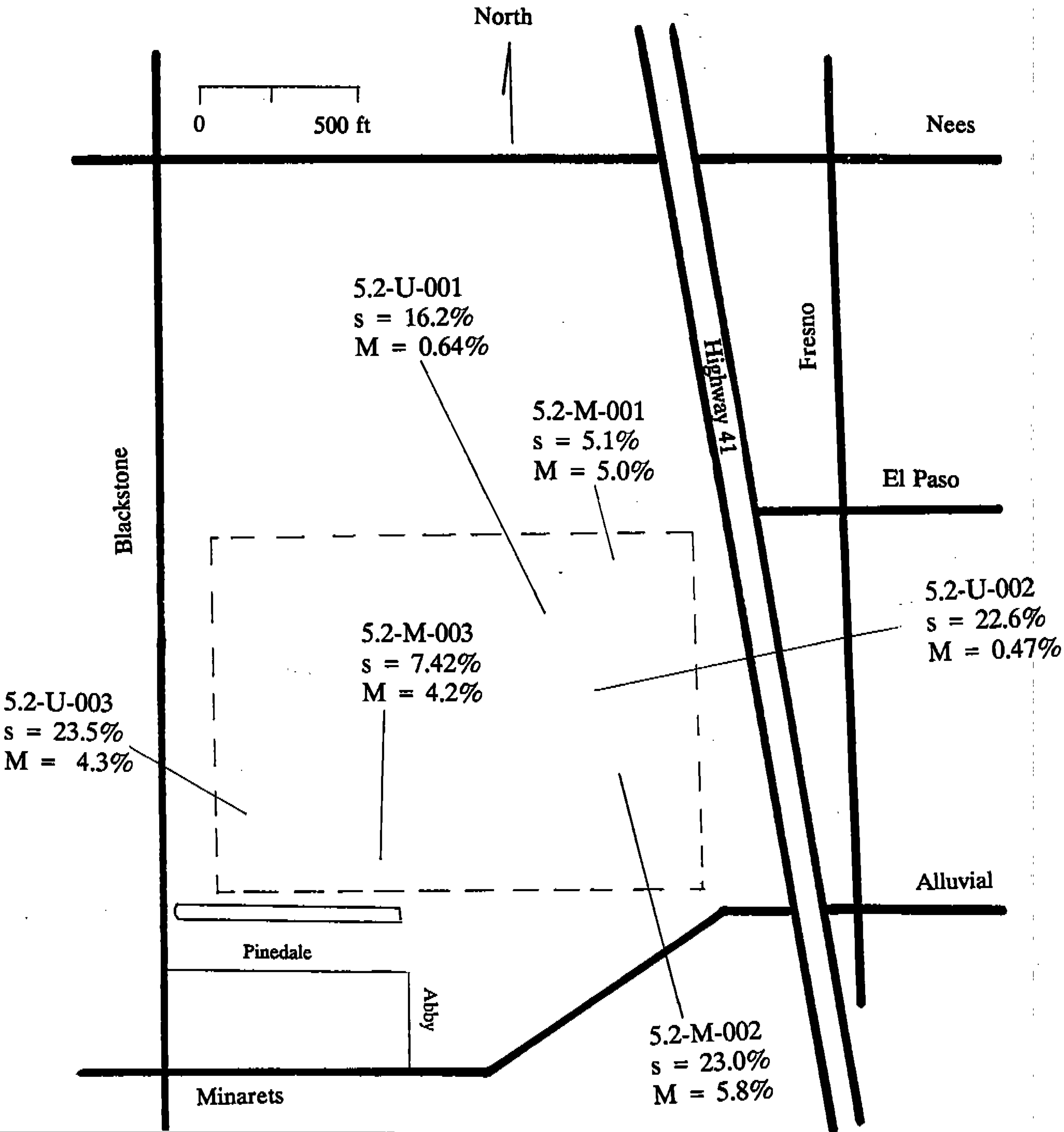
Figure 6. Site 3.2



Key: Material samples and analytical results coded as follows. Sample IDs consist of a 3-digit number preceded by a code letter:
- P - paved road sample
- U - unpaved road sample
- M - bulk material sample

Analysis results are coded as follows:
- M - surface moisture content (%)
- s - silt content (%)
- sL - surface silt loading (g/m^2)

Figure 7. Site 5.2

In summary, a total of seven construction sites were selected:

Site	Description\level of activity observed
1.1	Industrial park; moderate activity (trenching, prepaving, and small-scale earthmoving activities)
1.2	Residential construction; moderate activity (trenching) in Unit 1 and heavy activity (cut/fill) in Unit 2
2.1	Residential construction; moderate (trenching, prepaving) to heavy (trucking of road base) activity
2.2	Residential construction; low to moderate activity
3.1	Residential construction; heavy activity
3.2	Residential construction; heavy activity
5.2	Commercial development; moderate to heavy (trucking of fill material) activity

An eighth site (Site 1.3) was also visited; however, no major construction activity was in progress because trenching equipment was broken down. A copy of the field log is provided in Appendix A.

3.1.2 Demonstration Case Studies (Inventories)

At each site, a minimum of 2 days of observations were made. Separate observations were made in the morning and the afternoon, so there were a minimum of four observation periods for which inventories could be developed.

Both source activity and properties of the dust-emitting materials were needed to prepare the emission inventory. This required the collection of the following types of information:

- Traffic counts for primary haul routes on-site and access points to public roads
- Use counts for heavy equipment, such as bulldozers, graders, etc.
- Samples of:
  - Unpaved road surface material
  - Paved road surface material
  - Road base or other aggregate materials
  - Excavated materials (including that moved by scraper)

Material samples were analyzed for silt and moisture contents (as necessary) for use in the emission factors in Table 1.

As described in the test plan,[6] MRI used pneumatic traffic counters along the major travel routes and at main access point(s). To determine counter accuracy, 30-min visual observations of vehicle passes over each traffic counter were used. Observations were made both before and after the normal lunch break, and each observation period lasted at least 30 min.

For nonroad operations—such as scrapers, dozers, compactors, and excavators—and other operations that might damage a traffic counter hose, visual observations were used to determine cycle time and how many loads were completed. Note that, by selecting suitable vantage point(s), more than one set of visual observations could be recorded simultaneously.

Figures 1 through 7 also show the material samples collected at the sites. Sample collection followed the general procedures presented in Appendix C.1 in AP-42. Additional detail on sample collection and analysis are provided in the test plan.[6]

3.1.3 Focused Emission Measurements

Because few emission measurements had ever been collected specifically for construction sites, part of the field program was devoted to a second objective of collecting data to better define the applicability of "unit operation" emission factors to construction sites.

Preliminary planning called for testing to emphasize major on-site dust sources. The major sources could all be represented as line sources for the purpose of testing. Past studies indicated that the most important sources pertain to earthmoving (scrapers, graders, etc.) and truck haulage, with the handling of cut/fill and other materials representing a small fraction of total emissions.

Three sites—Sites 1.2, 2.1, and 3.1—were selected for the limited-scale emission testing. The sources tested were as follows:

Las Vegas Study Area

2 tests of scrapers traveling over an unwatered route at Site 1.2

South Coast Study Area

4 tests of scrapers traveling over an unwatered route at Site 3.1
2 tests of scrapers traveling over a watered route at Site 3.1

Coachella Valley Study Area

3 tests of captive light-duty vehicles traveling an unpaved route at Site 2.1

As discussed in the test plan,[6] the categories tested represent line sources and were evaluated using the exposure profiling method.

Emission testing employed the basic exposure profiling method. The technique uses a direct mass-balance calculation scheme similar to stack testing methods rather than relying on an uncalibrated dispersion model to indirectly back calculate an emission rate. Figure 8 shows equipment deployment for testing a line source such as traffic on an unpaved road or scraper movement. The sampling device was a high-volume ("hi-vol") air sampler fitted with a cyclone preseparator (Figure 9). The cyclone exhibits an effective 50% cutoff diameter of approximately 10 μmA when operated at a flow rate of 40 acfm (68 m^3/hr).[6] Samplers were fitted with volumetric flow controllers to maintain the desired flow rate and airborne particulate. Samples were collected on 8 in by 10 in glass fiber filters.

Additional detail on test methods, sample analysis, and data reduction are provided in the test plan.[6] In addition, the field logs in Appendix A describe the testing.

3.2 Paved Road Surface Silt Loading

The other major objective of the study was to provide a better paved road emission factor for use by BACM Working Group members. The AP-42 emission factor for paved roads depends on silt loading "sL," which represents mass of loose material less than 200 mesh present on the active road surface area. The magnitude of the silt loading, in turn, depends on numerous factors, including:

- The number, size, and speed of vehicles traveling the road
- Proximity to unpaved areas, such as parking lots, shoulders, and construction sites
- Degree to which the road is maintained
- Anthropogenic and naturally occurring consequences of weather (e.g., antiskid materials, and wind and water erosion)

The overall sampling scheme involved collection of eight sets of composite loading samples in each study area. The sets were broken down as follows. Roads in three zones were identified in conjunction with the study area liaison.

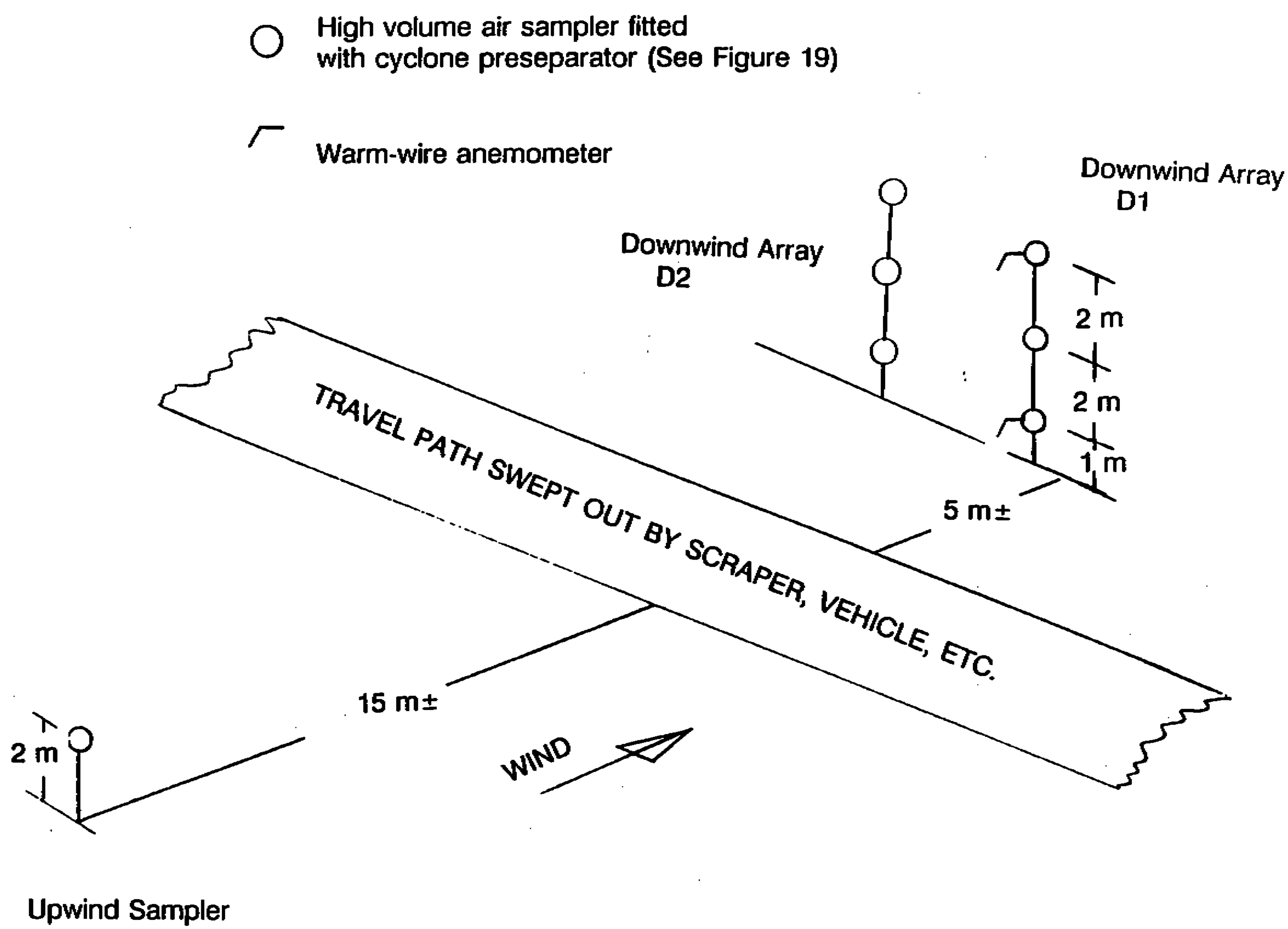


Figure 8. Equipment Deployment for Focused Emission Measurements

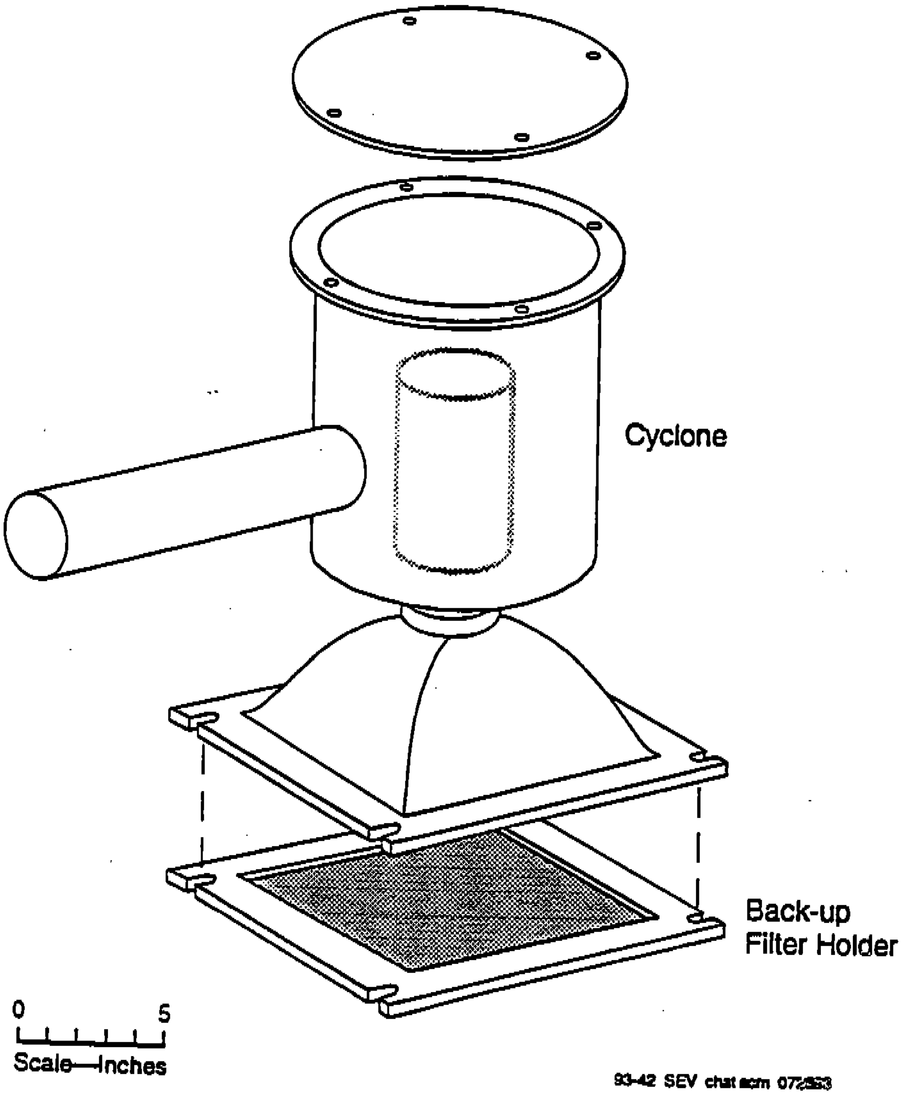


Figure 9. Cyclone Preseparator

Two zones were chosen to represent "nominal" conditions in the study area, while the third represented an area in which fairly extensive trackout from construction and other activities might be expected. The roads were classified as either high- or low-ADT.[c]

Recall that the objective of the sampling scheme was to provide a composite loading sample. In other words, a single silt-loading value would be determined for each zone/ADT combination from a series of sample increments taken of four to eight individual sites for each combination. Actual streets selected for sampling would provide reasonable geographic coverage, and actual sampling sites would be recorded on detailed street maps.

Sampling followed the procedures given in Appendix C.1 to AP-42.

During the April site visits, MRI collected two composite samples in each of the four study areas. The preliminary exercise allowed MRI to field-evaluate certain parameters, such as determining suitably sized areas for surface sampling and number of increments. Each preliminary composite sample consisted of four increments taken from a nominal (±5%) 200 ft^2 (18 m^2) area. Based on results from preliminary sampling, MRI modified its original plans so that roughly twice the total sample area (i.e., approximately 1,600 ft^2 [150 m^2]) was used.

The preliminary exercise also provided for a limited comparison of paved road surface-loading values at different times. The roads sampled in April in each area were resampled in June/July.

[c] No strictly quantitative method was used to distinguish between "low" and "high" ADT roads. Rather, roads were selected on the basis of how they were depicted on either city street maps or on functional classification maps provided by the study area contact person. Note also that no effort was made to collect surface material samples from limited access or very high-ADT roads. The decision is based primarily on safety concerns for the field crew.

Section 4
Data Analysis

This section discusses how the field data were analyzed to recommend improved emission estimation methods for construction activities and paved roads.

4.1 Recommended Emission Factor for On-Site Construction Activities

As noted in Section 3, emission inventories were prepared for the construction activities observed at each site during the morning (before lunch break) and afternoon. Inventories made use of the emission factors given in Table 1 together with observations and other data collection activities. The inventories are presented in Appendix B, and the results for each site are summarized in Table 3. The table presents the range, mean, and standard deviation of the estimated hourly PM_{10} emission rate for on-site construction activities. In addition, the mean hourly rate is divided by the area of the construction site to develop an overall area-based PM_{10} emission factor of the same sort as the old former AP-42 emission factor that has been used in inventories since 1975.

Given the range in size and level of activity from one site to another, it is not surprising that the overall, area-based emission factors range over two orders of magnitude. The geometric mean of the emission factors is 0.11 ton/acre-month. Substitution of this value for the original AP-42 emission factor represents the simplest revision that can be recommended based on the present study.

It is important to recall certain features of the inventories and, by extension, of any revised emission factor based on the inventories. First, two potentially important dust sources have not been included—wind erosion and mud/dirt trackout.

Wind erosion of areas exposed at construction sites can result in substantial emissions of particulate matter. Wind erosion requires that two events occur: (a) the area first must be disturbed so that the mitigating effects of crusting and compaction are destroyed and then (b) wind gusts above a threshold wind speed must occur. For construction that is associated with a limited time period, there are fewer opportunities for both events to occur. Furthermore, intensive anthropogenic activity that disturbs larger surface areas is usually concentrated in a relatively short period of time at a construction site. Thus, wind erosion is typically less important for construction sites than it is for areas (landfills, storage yards and staging areas, off-highway recreation sites, etc.) that are exposed to the wind throughout the year.

Table 3. Summary of Uncontrolled PM_{10} Emission Rates Estimated for the Construction Sites

Site	Estimated uncontrolled PM_{10} emission rate (lb/hr)		Site area (acre)	Overall uncontrolled PM_{10} emission factor	
	Range	Mean ± S.D.		(lb/acre-work hr)	(ton/acre-month)[a]
1.1	82 - 150	116 ± 28	300	0.39	0.032
1.2	67 - 161	133 ± 44	14 (Unit 1) 21 (Unit 2)	3.8	0.32
2.1	18 - 146	82 ± 73	86	0.95	0.080
2.2	0.68 - 0.81	0.74 ± 0.065	16	0.046	0.0039
3.1	300 - 494	393 ± 80	82	4.8	0.40
3.2	560 - 793	712 ± 104	140	5.1	0.43
5.2	82 - 228	164 ± 74	40	4.1	0.34
				Geometric mean: 1.3 x/÷ 5.9	Geometric mean: 0.11 x/÷ 5.9

[a] Based on 168 work-hours per month.

To estimate emissions from wind erosion at a particular construction site, the procedure presented in References 7 and 8 should be followed. The procedure (which is essentially the same as that given in AP-42 Section 13.2.5) has been automated and is contained in the "WIND" model available from the EPA's OAQPS bulletin board (919-541-5472). Section 5.3 presents an example of how wind erosion can be estimated for a specific construction site.

In addition, this study did not quantitatively address track-out of material from the surveyed construction sites onto adjacent paved roads. This construction-related, but off-site, source can often represent very substantial emissions. MRI staff photographed the access points and neighboring roads at the sites and found a wide variety of track-out effects.[d]

Trackout affects emissions from another source category (paved roads) contained in large-scale emission inventories. Thus, inclusion of trackout in a construction emission factor introduces the possibility of "double counting" emissions. Should one desire to estimate the emissions due to trackout from a specific construction site, then the procedure given in earlier EPA guidance documents should be followed. This approach is illustrated in Section 5.3.

Because the original AP-42 emission factor was based on air quality monitoring over areas that were several square miles in extent, any localized wind erosion on trackout would have affected the monitors and hence the resulting factor. It is not clear how much wind erosion or mud/dirt trackout was included in the original factor.

Furthermore, the emission inventories referenced uncontrolled conditions, and any emission factor based on these results also will reflect uncontrolled conditions. Most of the sites visited had water trucks controlling travel routes and applying water to any cut/fill areas. Information on water truck usage is provided in the field logs in Appendix A. Note that no water truck usage was included in the inventories in Appendix B.[e]

The 0.11 ton/acre-month value discussed above represents a straightforward means of revising current inventories with the direct substitution of one emission factor for another. However, direct substitution retains the same problems associated with the generality of the original factor. For example, it is unclear how well the distribution of inventoried sites matches the characteristics of construction sites in general: Do the inventoried sites contain a disproportionally large amount of earthmoving (scraper)

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[d] For example, trenching along the northern boundary of Site 1.2 required the temporary blocking of one travel lane of a public road. This forced westbound traffic to travel several hundred feet over an unpaved shoulder. Both sites in Newport Beach area, on the other hand, showed very little sign of track-out onto the public streets.

[e] Note that some of the focused emission measurements addressed the control effectiveness of watering travel routes. This is discussed in Section 4.2.

emissions? To at least partially account for the higher emission rates found for sites with active large-scale earthmoving operations, the overall area-based emission factor for Sites 1.2 (Unit 2), 3.1, 3.2, and 5.2 can be considered separately. As shown in a footnote to Table 4, this yields a worst-case overall factor of 5.0 lb/acre-work hr (or 0.42 ton/acre-month).

To account for differences in activity levels in another way, a second level of aggregation was undertaken to develop an improved emission factor. This approach recognizes that operations related to scrapers and truck movement of cut/fill and other materials typically accounted for far more than half of emissions estimated for a site. In the second level of aggregation, emissions related to (1) scraper pickup, movement, and unloading, and (2) truck dumping and haulage of fill or road base material were removed from the site totals. Remaining emissions were averaged and normalized by the site's area. The remaining emission estimates were deemed "general construction" and are shown in Table 4 together with the original overall factor.

The truck and scraper emissions were themselves normalized by dividing the hourly emission rate (lb/hr) by the product of (a) tons handled per hour and (b) the round trip **on-site** distance. For example, if a scraper transported cut material 500 ft to a fill area, then the round trip on-site distance would be 1,000 ft. On the other hand, if a belly dump truck entered a site at one access point, traveled 300 ft to a fill area and thereafter traveled 500 ft to another exit point, then the on-site round trip distance would be 800 ft.

The "general" area-based emission factors in Table 4 exhibit far less variability than do the overall factors presented earlier, presumably because they isolate the effect of important source contributions. Furthermore, even though the calculated scraper and truck haulage emission factors range over an order of magnitude, the ranges are far "tighter" than that given for the overall, area-based emission factor presented above.

The area-based emission factor of 0.11 ton/acre-month (0.42 ton/acre-month under worst-case conditions) described above represents a "Level 1" emission estimate. To develop an emission estimate more refined than Level 1, the following approach was undertaken. First, the general construction factors in Table 4 for Sites 1.1. 1.2, 2.1 and 5.2 were geometrically averaged to obtain 0.14 lb/acre-work hr (0.011 ton/acre-month). This value was considered to represent emissions due to construction activities exclusive of earthmoving and other large-scale movement of material. (Note that Sites 3.1 and 3.2 were excluded in the averaging because these were exclusively earthmoving projects, and Site 2.2 was excluded because of the low activity level during the field visit.)

Table 4. Second Aggregation of Estimated Emissions

Site	Area-based emission factor (lb/acre-work hr)		Material haulage factor (lb/ton-mile)[a]	
	General construction[b]	Overall	Range	Geo. mean
1.1	0.11	0.39	0.12 - 1.2 0.75 - 0.78	0.25 0.75
1.2	0.19[c]	6.2[d,e]	0.11 - 0.27	0.22
2.1	0.072	0.95	0.13 - 0.13 0.23 - 0.23	0.13 0.23
2.2	0.046	0.046	–	–
3.1	0.051	4.8[e]	0.13 - 0.32	0.19
3.2	0.017	5.1[e]	0.22 - 0.26	0.25
5.2	0.24	4.1[e]	0.18 - 0.46 0.13 - 0.13	0.28 1.3
	Geometric mean[f] 0.14 lb/acre-work hr		Range over all sites 0.11 - 1.2 0.23 - 1.3	Geometric mean 0.21 x/÷ 1.32 0.62 x/÷ 2.42

[a] Source extent is product of (a) mass of material transported times, (b) round trip on-site travel distance. See discussion in text. Table lists scraper emission factors unless two entries are given. In that case, the first factor represents scrapers, and the second represents over-the-road trucks (such as belly dumps) that can travel public streets.
[b] Excluding on- and off-site material haulage and handling.
[c] Unit 1.
[d] Unit 2.
[e] Value included in obtaining geometric mean factor of 5.0 lb/acre-work hr (0.42 (ton/acre-month) for sites with active large-scale earthmoving.
[f] Average of Sites 1.1, 1.2, 2.1, and 5.2.

A more refined emission estimate would make use of the base emission factor of 0.011 ton/acre-month and would add an estimate for emissions from earthmoving or other large-scale movement of materials. To account for emissions from such operations, MRI first developed mean hourly emission factors for scrapers and over-the-road trucks hauling construction materials (e.g., fill, road base, etc.). Tables 5 and 6 show how these factors were developed. The inventoried hourly emission rates attributable to scrapers in Appendix B were divided by the number of working scrapers. These values were averaged over all periods at a site when scrapers were observed to be operating. To account for differences in the size of scraper, Table 5 breaks down factors by the nominal capacity.

As in Table 5, the hourly emission rates in Appendix B attributable to truck movement were averaged over all periods at a site when truck movement was observed. However, unlike the "per-scraper" factors in Table 5, the emission factors for truck haulage in Table 6 are based on the total truck fleet hauling material to/from the site. This approach (rather than a "per-vehicle" basis) was adopted because the number of trucks used varies with the distance of construction site from the source/disposal site for the material. For example, if the material to be transported is nearby, two or three trucks might be enough to maintain efficiency in loading/unloading cycle. On the other hand, if the source is several miles away, then additional trucks would be necessary to maintain efficiency because more time is spent in travel.

As mentioned above, the more refined emission estimates use the base factor (0.011 ton/acre-month) and add estimates for emissions from material movement. Perhaps the most straightforward use would involve examining construction plans for the amount of material to be transported and how far material is to be moved on-site. In this case, the material haulage factors in Tables 4, 5 and 6 could be used. *However, this type of approach would require extensive information which cannot reasonably be assumed to be available to air regulatory personnel interested in areawide emission inventories.*

On the other hand, it is reasonable to assume that regulators may have access to the amount of cut/fill at a construction project. For example, the amount of cut and fill is requested in the application for a Clark County Air Pollution Control Division dust control permit. Furthermore, by comparing the applicant's response for amount of cut with the response for amount of fill, one can determine whether all earthmoving occurs on site or if material is to be transported to/from the site. In developing a "Level 2" estimate, it was assumed that agency personnel have access to this type of information.

In Level 2, emission estimates for earthmoving are based on knowledge of the amount of cut/fill. For on-site movement, it is assumed that one 30-cy scraper can move 70,000 cy of earth monthly. The basis of this and other assumptions is given in Appendix C. Using the average scraper emission factor of 49 lb/hr from Table 5, then a total of 4.1 ton/month is estimated for a 168-hr month. When this is divided by the 70,000 cy/month of moved, an emission factor of 0.059 ton/(1,000 cy) is obtained for on-site movement.

Table 5. Mean Emission Rates for Scrapers

Site	Mean PM_{10} scraper emission rate (lb/scraper-hr) by nominal scraper capacity[a]			
	10 cu yd	20 cu yd	30 cu yd	45 cu yd
1.1		31.1		
1.2			51.3	
2.1	10.9			
2.2				
3.1			47.6	62.2
3.2				114
5.2	32.0	64.6		
Geometric Mean	19	45	49	84

[a] Capacities correspond to Caterpillar Models 613, 623, 631/637, and 657. In the absence of other information, assume that:
a. scrapers are of 30 cu yd capacity.
b. four (4) scrapers are in use.

Table 6. Mean Emission Rates for On-Road Trucks

Site	Mean truck PM_{10} emission factor (lb/work hr)
1.1	34.5
1.2	
2.1	130
2.2	
3.1	
3.2	
5.2	186
Geo. Mean	94 lb/work hr = 7.9 ton/month

Appendix C also describes the basis for the assumption that 35,000 cy can be transported to/from by truck per month. Based on the average truck factor of 7.9 ton/month in Table 6, an off-site factor of 0.22 ton/(1,000 cy) results.

Table 7 summarizes the recommended emission estimating procedure. *Level 1 corresponds to only information that is available in any current inventory based on the original AP-42 emission factor.* Level 2 is based on information that could be obtained through review of building or dust control permits. Development of the necessary information is discussed in Section 4.4.

Table 7 also presents Level 3 and Level 4. These correspond to the straightforward use of the emission factors in Tables 4 through 6. As mentioned earlier, Levels 3 and 4 require information on how and what types of equipment are used at the site. Level 4, in particular, requires detailed knowledge and probably represents a methodology that can only be used to generate site-specific rather than areawide emission estimates. *Although not intended for use in large-scale emission inventories,* these two levels may be useful estimation tools when specific construction sites are of interest.

4.2 Focused Emission Measurements

As discussed earlier, very limited data exist against which the performance of Table 1 emission factors can be assessed. The field program described in Section 3 developed independent data that can be used for this purpose. Testing parameters are given in Table 8. Table 9 presents the results of the limited-scale emission measurements, and Table 10 compares predicted and measured emission factors for the two source categories considered.

Measured uncontrolled scraper travel emission ranged over roughly one order of magnitude. The emission factor equation developed from tests at surface coal mines underpredicted emissions in Las Vegas but overpredicted emission levels in Newport Beach. On average, the equation overpredicted by approximately 30%.

Tests BA-8 and -9 suggest that watering can afford control efficiencies of 60% to 90% at construction sites.

The AP-42 unpaved road equation underpredicted emission factors measured in the focused emission tests. Underprediction is at least partially due to the unimproved (i.e., no base material or compaction) nature of the travel surface at Site 2.1. Previous tests also have shown that the unpaved road underestimates emissions from unimproved surfaces. In addition, the route did not appear to have been recently traveled. This is presumed to be the reason that the emission factor grew from one test period to another.

Table 7. Recommended Emission Estimation

Basis for emission factor	Recommended PM_{10} construction emission factor
Level 1—Only area and duration known	Apply 0.11 ton/acre-month (average conditions) 0.42 ton/acre-month (worst-case conditions)
Level 2—Area and amount of earthmoving known	Apply 0.011 ton/acre-month for each month of construction activity **Plus** 0.059 ton/1,000 $yard^3$ of on-site cut/fill 0.22 ton/1,000 $yard^3$ of off-site cut/fill These values are based on an assumption that one scraper can move 70,000 $yard^3$ of earth in one month and 35,000 $yard^3$ of material can be moved by truck in one month. If the on-/off-site fraction is not known, assume 100% on-site.
Level 3—More detailed information available on duration of earthmoving and other material movement.	Apply 0.13 lb/acre-work hr **plus** 49 lb/scraper-hr for on-site haulage[a] 94 lb/hr for off-site haulage[b]
Level 4—Detailed information on number of units and travel distances available	Apply 0.13 lb/acre-work hr **plus** 0.21 lb/ton-mile for on-site haulage 0.62 lb/ton-mile for off-site haulage[b]

[a] If the number of scrapers in use is not known, a default value of 4 may be used. In addition, if the actual capacity of earthmoving units is known,. use values given in Table 5.

[b] Factor for use with over-the-road trucks. If "off-highway" trucks are used haulage should be considered "on-site."

Table 8. Test Site Parameters for the Focused Emission Measurements

Run	Date	Site	Description	Start time	Stop time	No. of vehicle passes	Avg. temp. (°F)	Avg. B.P. (inHg)
BA-1	6/21/95	1.2	Scraper—uncontrolled	14:01	14:44	19	91	27.50
BA-2	6/21/95	1.2	Scraper—uncontrolled	14:53	15:15	12	91	27.50
BA-3	6/26/95	3.1	Scraper—uncontrolled	14:45	15:25	17	74	27.20
BA-4	6/26/95	3.1	Scraper—uncontrolled	14:45	15:25	17	74	27.20
BA-5	6/26/95	3.1	Scraper—uncontrolled	15:42	16:38	14	74	27.10
BA-6	6/26/95	3.1	Scraper—uncontrolled	15:42	16:38	16	74	27.10
BA-8	6/30/95	3.1	Scraper—controlled	11:16	11:29	42	70	26.30
BA-9	6/30/95	3.1	Scraper—controlled	13:15	13:31	74	70	26.30
BA-10	7/13/95	2.1	Light duty—uncontrolled	13:43	14:12	32	105	29.86
BA-11	7/13/95	2.1	Light-duty—uncontrolled	14:51	15:26	29	105	29.86
BA-12	7/13/95	2.1	Light duty—uncontrolled	15:53	16:21	31	105	29.85

Table 9. Measured PM_{10} Emission Factors

			Scrapers				All traffic			
Run	Silt (%)	Moisture (%)	Average speed (mph)	Average weight (ton)	Average wheels	Measured PM_{10} emission factor (lb/VMT)	Average speed (mph)	Average weight (ton)	Average wheels	Measured PM_{10} emission factor (lb/VMT)
BA-1	7.69	1.16	9.5	57.4	4.0	6.76	8.8	54.8	4.2	6.05
BA-2	7.69	1.16	9.5	58.5	4.0	11.1	9.5	58.5	4.0	11.1
BA-3	6.04	7.41	14	86.5	4.0	1.32	14	86.5	4.0	1.32
BA-4	6.04	7.41	14	86.5	4.0	0.578	14	86.5	4.0	0.578
BA-5	6.04	7.41	14	87.7	4.0	1.34	14	77.0	4.0	1.17
BA-6	6.04	7.41	14	87.7	4.0	0.635	14	77.0	4.0	0.553
BA-8	4.11	4.14	16	94.0	4.0	0.369	16	86.7	4.1	0.335
BA-9	3.35	5.69	16	87.1	4.0	0.101	16	79.6	4.1	0.0904
BA-10	15.54	0.27					25	2.8	4.3	3.33
BA-11	15.54	0.27					25	2.0	4.0	9.10
BA-12	15.54	0.27					25	2.0	4.1	12.5

Table 10. Comparison of Table 1 Emission Factors and Measurements

Source category	No. of tests	Mean predicted to measured ratio	
		Range	Mean
Scraper in travel mode			
Site 1.2	2	0.15 - 0.24	0.19
Site 3.1	4	2.42 - 5.52	3.61
Overall		0.15 - 5.52	1.35
Unpaved surface	3	0.14 - 0.68	0.26

Overall, the results from comparing limited field emission measurements to estimated values proved inconclusive, with no clear-cut tendency for over- or underprediction. As such, no changes were made to the emission factors presented in Table 1 for use in developing the construction site inventories.

4.3 Paved Road Emission Factors

Table 11 summarizes the spatially averaged silt and total loading values collected from the four study areas. As expected, all low ADT roads exhibited far higher sL values than did the high ADT roads in the same zone. In general, the low ADT roads had sL values 3 to 10 times higher.

As noted in Section 2, there are good reasons to suspect that the AP-42 sL database is skewed high. The results obtained here support those suspicions. Figures 10 and 11 compare the silt loadings obtained for high-ADT and low-ADT roads against the corresponding values in AP-42. As can be seen from the figures, median sL values measured in this study are roughly 5 to 10 times lower than in AP-42. In fact, some of the high-ADT roads were associated with sL values slightly lower than the AP-42 default value for limited access roads (i.e., 0.02 g/m^2).

Repeat sampling between the April and June/July visits led to the following summary statistics:

Study area	Road class	Range percent[a]
Las Vegas	Low ADT	14%
	High ADT	45%
South Coast	Low ADT	110%
	High ADT	4.5%
Bakersfield	Low ADT	93%
	High ADT	113%
Coachella Valley	Low ADT	132%[b]
	High ADT	31%

[a] Defined as (high - low)/(average) × 100%.
[b] Significant construction track-out observed during April sample.

Table 11. Paved Road Surface Sampling Results

Sampling location	Medium and heavy duty vehicle passes (% of total)[a]	Total loading (g/m²)[b]	Silt loading (g/m²)[b]
Las Vegas			
Repeat Low ADT—Spring Mountain, Pioneer, Desert Inn, Odette		1.68/1.46	0.084/0.097
Repeat High ADT—Rainbow, Jones, Tropicana, Charleston	9.9	1.88/0.90	0.052/0.033
Residential Low ADT—Edison, Phoenix, Surrey, Boca Grande		14.2	1.27
Residential High ADT—Russell, Sandhill, Pecos, Desert Inn	3.3	1.20	0.029
Industrial Low ADT—Harmon, Ali Baba, Saddletree, Red Oak		4.74	0.28
Industrial High ADT—Western, S. Highland, Industrial, Valley View	10.8	7.19	0.20
South Coast			
Repeat Low ADT—Maple, Simmons, Willowwood, Struck		1.49/0.90	0.184/0.054
Repeat High ADT—Crown Canyon, Golden Lantern, Moulton, Alicia	2.2	0.091/0.13	0.012/0.015
Orange County (C-5) Low ADT—Stewart, Walnut, Varsity, Palm		1.90	0.17
Orange County High ADT—Glassel, Katella, Main, Garden Grove	2.3	0.21	0.011
San Fernando Low ADT—Noble, Orion, Tupper, Gledhill		2.24	0.14
San Fernando High ADT—Nordhoff, Plummer, Woodman, Devonshire	1.0	0.69	0.046
Bakersfield			
Repeat Low ADT—Calloway, Seabeck, Pacheco, Winter Ridge		1.03/0.99	0.52/0.19
Repeat High ADT—H, Planz, Stine, Ashe	1.5	0.65/0.56	0.054/0.015
Northeast Residential Low ADT—St. Marys, Rampart, Wendy, Oakridge		16.5	0.94
Northeast Residential High ADT—Columbus, Fairfax, Panorama, Mt. Vernon	1.3	0.43	0.051
Industrial Low ADT—Inyo, Kentucky, Lincoln, Chico		8.94	0.41
Industrial High ADT—Truxton, Baker, Bernard, Monterey	0.5	0.38	0.039
Coachella Valley			
Repeat Low ADT—Miles, Dune Palms, Westward Ho, Desert Stream		22.4[c]/4.27	2.04[c]/0.42
Repeat High ADT—Dinah Shore, Ramon, Gene Autry, Sunrise	3.0	0.55/1.73	0.027/0.037
City of Coachella Low ADT—Frederick, Westerfield, Tripoli, Cypress		6.28	0.35
City of Coachella High ADT—Harrison, 52nd, Grapefruit, 50th	3.1	1.49	0.082
Palm Desert Low ADT—Desert Lily, Rutledge, Merle, Deep Canyon		3.07	0.20
Palm Desert High ADT—Fred Waring, Monterey, Country Club, El Paseo	4.4	0.87	0.030

[a] During the high ADT sampling periods in June/July, MRI began a count of 100 vehicles once a medium- or heavy-duty vehicle was observed. This method provides an average vehicle weight that is slightly high.
[b] If two values are given, the first is the result from the April visit and the second, the value from the June/July visits.
[c] These roads exhibited noticeable trackout from a construction area.

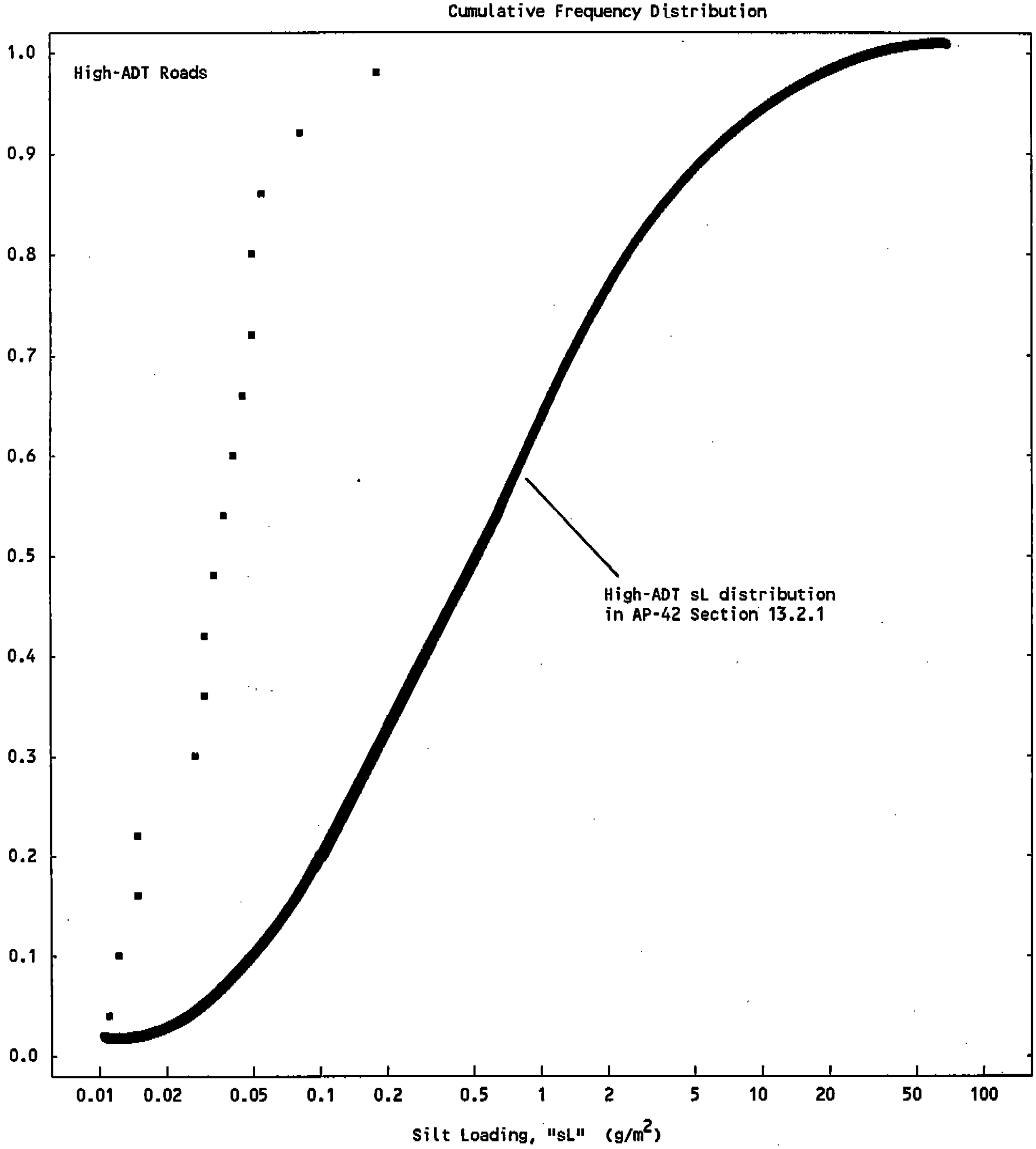


Figure 10. Comparison of Silt-Loading Values Obtained in This Study with AP-42 Database for High-ADT Roads

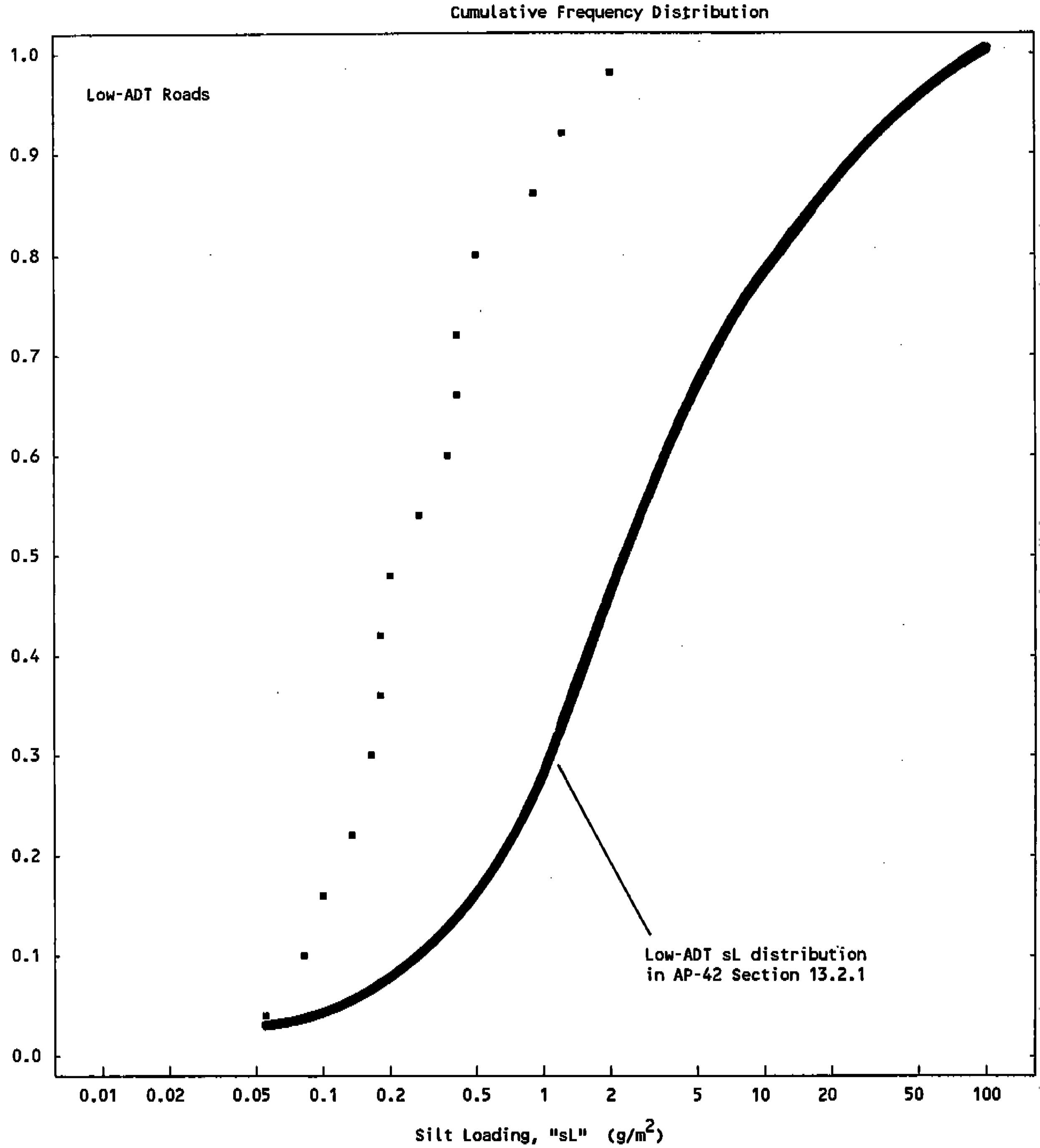


Figure 11. Comparison of Silt-Loading Values Obtained in This Study with AP-42 Database for Low-ADT Roads

The repeat sampling results suggest that sL values may vary substantially over time. However, because sL is raised to a power less than one in the AP-42 paved road equation, the resulting variation in the estimated emission factor is less pronounced. No seasonal trend was found in the samples. In comparing the eight repeat samples, five June/July sL were greater and three were lower than the corresponding April values.

Table 11 also presents non-light-duty fraction of vehicles observed during the road sampling program. The overall mean ratio is 2.5%, and the corresponding mean vehicle weight is conservatively estimated as 2.4 tons. Table 12 summarizes the paved road emission factors recommended for general use.

Table 12. Recommended Paved Road PM_{10} Emission Factors

	Emission factor (g/VMT)		
	High-ADT	Low-ADT	Average[a]
Average conditions[b]	0.37	1.3	0.81
Worst-case conditions[c]	0.64	3.9	2.1

[a] Based on 65% of high- and 35% of low-ADT sL value.
[b] Based on median value and 2.4 tons.
[c] Based on 90th percentile and 2.4 tons.

In addition, member agencies may choose to employ the individual sL and mean vehicle data in the same manner that AP-42 encourages readers to use the silt-loading values presented in AP-42. That is, AP-42 recognizes that end users of that document are the most capable of identifying which roads in the database are similar to roads of interest to them.

4.4 Collection of Information Needed for Construction Emission Factors

As noted in Section 4.1, progressively more detailed information is needed to employ the different levels of emission factors recommended in Table 7. Working Group member agencies are not expected to have the information readily available; however, collection of the information appears to be a relatively straightforward process. The following describes a questionnaire to collect the information and discusses how the data may be reduced.

For several years, the Clark County (Nevada) Department of Health has issued a permit to disturb topsoil. The application for that permit asks for the amount of cut and fill material at a particular site. Figures 12 and 13 show an example questionnaire (based on the Clark County application form) that requests the types of information needed to employ Levels 2 through 4 in Table 7. It is recommended that a member agency submit this questionnaire to major earthmoving contractors doing work within the agency's jurisdiction. A cover letter should ask that contractors complete the questionnaire (for example) for projects over 10 acres performed during the past 2 years. Alternately, an agency may ask a contractor to keep records for each successful bid in the coming year and submit the information to the agency at the end of that time.

Once the agency has assembled the responses, the data may be aggregated and analyzed in several ways. For example, an agency may choose to construct an estimate of the amount of cut/fill and other materials on the basis of a site's area and duration of the project. Summary statistics could be used to determine study area-specific default values (e.g., number of scrapers in use, vehicle capacity).

Name of Construction Project ______________________

Project Address ______________________

Project Acreage ______
(acres)

Amount of material used in Cut process ______________ (banked cu yd)

Amount of material used in Fill process ______________ (compacted cu yd)

Please specify off-road equipment used in Cut/Fill process:

Equipment	No. of Units	Make/ Model No.	Capacity (cu yd)	Estimated haul distance (ft)[a]	No. of Months to be used at site
Scraper					
Off-highway truck					
Loading tool - Wheel Loader - Excavator					
Compactor					
Grader					

[a] Complete for scrapers and trucks only.

(over)

Figure 12. Front Page of Questionnaire

Please specify over-the-road equipment used in Cut/Fill process:

Equipment	No. of Units	Capacity (cu yd)	No. of Months to be used at site	Estimated total travel distance on-site (ft)
Belly dump trucks				
Rear dump trucks				
Other (specify)				

Please specify the amount of other major materials that will be trucked in (e.g., road base, concrete, etc.).

Please specify the over-the-road vehicles that will be used to truck these materials to the site.

Equipment	Total Amount of Material	Capacity (cu yd)	No. of Months to be used at site	Estimated total travel distance on-site (ft)
Belly dump trucks				
Rear dump trucks				
Other (specify)[b]				

[b] NOTE: If any off-road vehicles will be used to move materials on-site, please include here.

Figure 13. Back Page of Questionnaire

MRI-ENVIRON\R3855-01.2

Section 5
Example Use of the Factors Recommended for Construction

This section presents examples showing how to use the emission factors recommended for construction sites. The examples follow the same order as do the levels in Table 7 and illustrate how additional information is needed as one progresses from one level to the next. The additional information needed to employ the different levels is *underlined* at the time it is needed.

5.1 Site 3.1

The first example is based on Site 3.1 and concerns a 82 acre site with 1,500,000 cubic yards (cy) of on-site cut/fill activity over a 3-month period. The *Level 1 estimate makes use only of the site's area and the project duration*:

- 82 acres in size
- 3 month duration

Estimated PM_{10} Emissions	=	0.11 ton/acre-month x 82 acre x 3 month
	=	9.0 ton/month x 3 month
	=	27 ton

A improved Level 1 ("Level 1a") estimate is possible because we *know that the site involves active earthmoving* and thus the worst-case value of 0.42 ton/acre-month can be used.

Estimated PM_{10} Emissions	=	0.42 ton/acre-month x 82 acre x 3 month
	=	34 ton/month x 3 month
	=	100 ton

The Level 2 estimate requires additional information—namely, *the amount of cut/fill*:

- 82 acres in size
- 3 month duration
- Active earthmoving underway
- 1,500,000 cy of earth to be moved (all on-site)

Thus, emissions are estimated in Level 2 as

$$
\begin{aligned}
\text{Estimated PM}_{10}\text{ Emissions} &= 0.011 \text{ ton/acre-month x 82 acre x 3 month +} \\
&\quad (0.059 \text{ ton/1,000 cy) x 1,500 (1,000 cy)} \\
&= 0.90 \text{ ton/month x 3 month + 88 ton} \\
&= 91 \text{ ton}
\end{aligned}
$$

In Level 3, even more information is necessary. In this case, we know that *8 scrapers are used,* but we do not know how large the scrapers are:

- 82 acres in size
- 3 month duration
- Active earthmoving underway
- 1,500,000 cy of earth to be moved (all on-site)
- Eight scrapers in use, but size unknown (i.e., use default emission factor)

Thus, the Level 3 estimate (using the default scraper factor of 49 lb/scraper-hr) is given as

$$
\begin{aligned}
\text{Estimated PM}_{10}\text{ Emissions} &= 0.011 \text{ ton/acre-month x 82 acre x 3 month +} \\
&\quad (49 \text{ lb/scraper-hr) x 8 scraper x 3 month} \\
&= 0.90 \text{ ton/month x 3 month + 390 lb/hr x} \\
&\quad 168 \text{ hr/month x 3 month} \\
&= 2.7 \text{ ton + 98 ton} \\
&= 100 \text{ ton}
\end{aligned}
$$

A refined Level 3 ("Level 3a") estimate requires that we know the capacity of the equipment used. At site 3.1, *four 30-cy and four 45-cy scrapers were used, and size-specific scraper emission factors from Table 5 are be used*:

- 82 acres in size
- 3 month duration
- Active earthmoving underway
- 1,500,000 cy of earth to be moved (all on-site)
- Four 45-cy and four 30-cy scrapers

$$
\begin{aligned}
\text{Estimated PM}_{10}\text{ Emissions} &= 0.011 \text{ ton/acre-month x 82 acre x 3 month +} \\
&\quad (49 \text{ lb/scraper-hr) x 4 scraper x 3 month +} \\
&\quad (84 \text{ lb/scraper-hr) x 4 scraper x 3 month} \\
&= 0.90 \text{ ton/month x 3 month + 190 lb/hr x} \\
&\quad 168 \text{ hr/month x 3 month + 340 lb/hr x} \\
&\quad 168 \text{ hr/month x 3 month} \\
&= 2.7 \text{ ton + 134 ton} \\
&= 140 \text{ ton}
\end{aligned}
$$

Under Level 4, even more detailed information is needed about the *length of the average (round-trip) distance traveled and the density of the material*:

- 82 acres in size
- 3 month duration
- Active earthmoving underway
- 1,500,000 cy of earth to be moved (all on-site)
- Four 45-cy and four 30-cy scrapers in use
- Average haul distance ~ 3,000 ft
- Earth density 1.4 ton/cy

Estimated PM_{10} Emissions = 0.011 ton/acre-month x 82 acre x 3 month + 0.21 lb/ton-mile x 1,500,000 cy x 1.4 ton/cy x 3,000 ft
= 0.90 ton/month x 3 month + 125 ton
= 130 ton

The following table compares the different estimates with the results from the mean inventoried emissions from the demonstration study:

Level	Estimated PM_{10} emissions (tons)	Area-normalized emissions (ton/acre-month)
1	27	0.11
1a	100	0.42
2	91	0.37
3	100	0.41
3a	140	0.56
4	130	0.52
Average inventory result based on values in Table 3	99 ± 20	0.40 ± 0.081

5.2 Site 3.2

A second example is based on Site 3.2. Here, 3,000,000 cy of earth are to be cut/filled over a 6-month period. The site is 140 acres in size. The *Level 1 estimate makes use only of the site's area and the project duration*:

- 140 acres in size
- 6 month duration

Estimated PM_{10} Emissions	=	0.11 ton/acre-month x 140 acre x 6 month
	=	92 ton

The Level 1a estimate makes use of the worst-case factor because we know that *the site contains large-scale active earthmoving*:

Estimated PM_{10} Emissions	=	0.42 ton/acre-month x 140 acre x 6 month
	=	350 ton

Use of Level 2 that we supply information on *the amount of cut/fill*:

- 140 acres in size
- 6 month duration
- Active earthmoving underway
- 3,000,000 cy of earth to be moved (all on-site)

Thus the Level 2 estimate is given by

Estimated PM_{10} Emissions	=	0.011 ton/acre-month x 140 acre x 6 month + (0.059 ton/1000 cy) x 3,000 (1,000 cy)
	=	186 ton

In Level 3, even more information is necessary. In this case we know that *8 scrapers are used*, but we do not know how large the scrapers are:

- 140 acres in size
- 6 month duration
- Active earthmoving underway
- 3,000,000 cy of earth to be moved (all on-site)
- Eight scrapers in use, but size unknown (i.e., use default emission factor)

Under Level 3 (with the default scraper factor of 49 lb/scraper-hr), the emissions are estimated as

Estimated PM_{10} Emissions = 0.011 ton/acre-month x 140 acre x 6 month + (49 lb/scraper-hr) x 8 scraper x 6 month
= 207 ton

A refined Level 3 ("Level 3a") estimate requires that we know *size of the actual equipment in use* at the site. At Site 3.2, all 8 scrapers are 45 cy in capacity, and the size-specific scraper factor from Table 5 is used:

- 140 acres in size
- 6 month duration
- Active earthmoving underway
- 3,000,000 cy of earth to be moved (all on-site)
- Eight 45-cy scrapers in use

Estimated PM_{10} Emissions = 0.011 ton/acre-month x 140 acre x 6 month + (84 lb/scraper-hr) x 8 scraper x 6 month
= 348 ton

Level 4 requires detailed information on the *length of the average (round-trip) haul distance and the material density*:

- 140 acres in size
- 6 month duration
- Active earthmoving underway
- 3,000,000 cy of earth to be moved (all on-site)
- 845-cy scrapers in use
- Average haul distance ~ 3,000 ft
- Earth density 1.4 ton/cy

Estimated PM_{10} Emissions = 0.011 ton/acre-month x 140 acre x 6 month + 0.21 lb/ton-mile x 3,000,000 cy x 1.4 ton/cy x 3,000 ft
= 343 ton

The following table compares estimates from the different levels with the mean inventoried value:

Level	Estimated PM_{10} emissions (tons)	Area-normalized emissions (ton/acre-month)
1	92	0.11
1a	350	0.42
2	186	0.22
3	207	0.25
3a	348	0.41
4	343	
Average inventory result based on values in Table 3	360 ± 52	0.43 ± 0.063

5.3 Estimates of Wind Erosion and Mud/Dirt Trackout

As discussed earlier, the estimation methods recommended in Table 7 do not include emissions due to wind erosion and trackout. This section presents examples of how to estimate emissions from those two emission sources. The examples are based on Site 3.1.

5.3.1 Wind Erosion

Wind erosion was estimated using the procedure contained in the "WIND" model available through the OAQPS bulletin board (919 541-5472). The procedure is identical to that presented in References 7 and 8, and closely parallels the approach given in AP-42 Section 13.2.5, "Industrial Wind Erosion."

Figure 14 presents the output from the WIND model run using the data for Site 3.1. Several items should be noted:

1. Approximately 10 acres at the 80-acre site were considered erodible. This corresponds to the open area used for equipment storage and the roadways. Both are disturbed daily and are open to the wind.

2. The estimation procedure requires that one year of daily fastest miles of wind be available. The meteorological file used here was the example file "LCDXMPL.MET" which is supplied with the WIND program.

```
                    Spreadsheet as of 11:53:56  on 03-25-1996

Input Filename: openare.ef
Inventory area: Example - Site 3.1,2
Source ID: open area  Filename: c:\wind@x@y\files\openare.EF

Emissions estimate year:     1995
Based on wind data year:     1990
Fastest mile filename:      lcdxmpl.met
System of units:     English
Source life (inclusive days of year)
     Start day: 1
       End day:  30
F=flat area, PC=conical pile, PO=oval pile:     F
 Area (acres):      1
Material description:     Surface material
Percent moisture content:     5
Percent  silt content:
Threshold friction velocity, U*t, (cm/sec):      77.70894
Roughness height (cm):      1
Mode (mm) of size distribution      .59      (# denotes calculated value)
Lc value (cf. Fig. 6-3 of reference manual):      .01


Frequency of disturbance information :
 Us/Ur =  1 -- subarea #  1      -- 100 % of regime disturbed every 1 day(s)



Total emissions emitted over the period:  13480.15 g


Threshold velocity =  77.70894  cm/s
Control:  Effective windspeed ratio =  1

-------------------------------------------------
Us/Ur =  1     Disturbance interval = 1  days

Period  5 - 6  high on  6   .7915031  m/s  753.5366  g emitted
Period  6 - 7  high on  7   .8187963  m/s  2313.998  g emitted
Period  7 - 8  high on  7   .8187963  m/s  2313.998  g emitted
Period  10 - 11  high on  11   .8460895  m/s  4049.311  g emitted
Period  11 - 12  high on  11   .8460895  m/s  4049.311  g emitted

Summary for Us/Ur =  1       Disturbance Interval =  1
 13480.15  Total g emitted over  1  -  30
-----------------------------------------------------------------
Summary for entire source:  13480.15    g emitted over period  1  -  30
NOTE: For a variety of reasons given in the user manual, the erosion estimates
      presented above may be considered as CONSERVATIVELY HIGH.  See the
      user manual for more information.
```

Figure 14. Output from WIND Model

3. The threshold wind speed was based on the mode of the particle size distribution of the sample (Sample number SC U 003 in Figure 5) collected from the open area used for equipment storage. The largest fraction of material was caught between the 20 and 40 mesh screens. The size distribution mode was taken as equal to 0.59 mm, which is the geometric mean of 20 and 40 mesh openings (0.833 and 0.417 mm, respectively).

4. The mode of 0.59 mm was used by the model to estimate a threshold friction velocity of approximately 78 cm/sec. A roughness height of 1 cm was assumed for the surrounding area.

5. The area was modeled as a flat 1-acre site. Furthermore, only one month was considered in the example calculation, for the purposes of illustration. In this case, total PM_{10} wind erosion emissions are estimated as 13,500 g (29.7 lb). To obtain total emissions for the approximately 10 acres considered erodible over the 3-month-long period that the site is active, one must multiply the that result by 30 to obtain 890 lb.

5.3.2 Mud/Dirt Trackout

The EPA guidance document "Control of Open Fugitive Dust Sources" (EPA-450/3-88-008) presents a means to estimate PM_{10} emissions from mud/dirt trackout. For an individual access point from a paved road to a construction/demolition site, the PM_{10} emission increase ΔE (in g/day) is estimated as

$$\Delta E = e\ M$$

where: e = unit emission increase (equals 5.5 g/vehicle if fewer than 25 vehicles enter or leave the site daily and equals 13 g/vehicle otherwise)

M = number of vehicle passes per day on the adjacent public paved road

At Site 3.1, more than 25 vehicles entered or left the site each day. Assuming that approximately 1,000 vehicles pass the access point on Pelican Hill Road (see Figure 5), then the daily emission increase is

$$\begin{aligned}\Delta E &= 13 \text{ g/vehicle} \times 1{,}000 \text{ vehicle/day} \\ &= 13 \text{ kg/day}\end{aligned}$$

Over the 3-month (90 day) period, a total of 1,200 kg (2,600) is estimated as being emitted due to trackout. Note that this estimate reflects uncontrolled conditions whereas the access point Site 3.1 was cleaned at least twice per day.

Section 6
Conclusions and Recommendations

Based on information presented in the report, the following conclusions and recommendations can be made.

1. It is recommended that BACM working group members substitute the revised construction emission factor of 0.11 ton/acre-month in place of the original AP-42 factor. The new factor references PM_{10} rather than TSP emissions.

2. MRI recommends that member agencies consider developing information needed to be used with Levels 2 and 3 in Table 7. For some agencies, such as Clark County, a database could be constructed relatively easily by combining permit application information with default values for scraper capacities, etc. Other agencies may find it necessary to develop information "from scratch." It is recommended that agencies consider collecting one or two years of data using a survey instrument such as that presented in Section 4.4.

3. It is recommended that member agencies refrain from using default values presented in AP-42 Section 13.2.1 and other EPA guidance documents when preparing emission inventories for public paved roads within their jurisdictions. Based on data collected in this study, road surface silt loadings are roughly an order of magnitude lower than the defaults.

4. The focused emission measurement results were inconclusive in establishing how well emission factors developed for other industries predict emissions from construction operations. On average, agreement was fairly acceptable. However, this reflected balancing of substantial overprediction at one site with underprediction at a second site. Additional field tests will be necessary to provide better answers to questions involving the applicability of Table 1 emission factors to construction activities.

5. It is recommended that any future field tests of emissions from earthmoving activities be closely coordinated with a long-term earthmoving project and that tests be conducted as early as practical. In this way, longer haul distances will be available and there will be less wind interference from cut/fill areas and stockpiles.

Section 7
References

1. U.S. EPA. Compilation of Air Pollutant Emission Factors (AP-42). Fifth Edition. Research Triangle Park, North Carolina.

2. *Caterpillar Performance Handbook.* 23rd Edition. Caterpillar, Inc., Peoria, Illinois. October 1992.

3. Midwest Research Institute. Review and Update of Miscellaneous Sources in Chapter 11, AP-42—Summary Report. EPA Contract No. 68-D0-0123, Work Assignment No. II-44. April 1993.

4. Englehart, P. J., and G. E. Muleski. Open Fugitive Dust PM_{10} Control Strategies Study. Final report prepared for SCAQMD. July 1990.

5. Midwest Research Institute. Characterization of Mud/Dirt Carryout onto Paved Roads from Construction and Demolition Activities. EPA Contract No. 68-D0-0123, Work Assignment No. II-44. September 1994.

6. Muleski, G. E., and G. Garman. Improvement of Specific Emission Factors (BACM Project No. 1). Site-Specific Test Plan prepared for SCAQMD. June 1995.

7. Cowherd, C., G. E. Muleski, and J. S. Kinsey, "Control of Open Fugitive Dust Sources," EPA-450/3-88-008, U.S. EPA, Research Triangle Park, NC, September 1988.

8. Muleski, G. E., and R. F. Hegarty, "User's Manual for PM-10 Open Fugitive Dust source Computer Model Package," EPA-450/3-90-010, U.S. EPA, Research Triangle Park, NC, April 1990.

Appendix A

Photocopies of the Field Logs

MRI Project No.: 3855 | Performed by (name/date):
Title/Purpose:

Continued from: | Continued to: | Entered by: GM | Verified by:
Witnessed by: | | Reviewed by: | Validated by:
Witnessed by:

(signature/date) | (initials/date) | (initials/date)

6/19/95 MONDAY

GM lv. KC 5am CDT, arrive LV via St Louis @ ~11am PDT — ~~drive by~~ took cab to get PU — drive by Site 1.2. (Russell & Rainbow) lunch 11:45 to 12:30 — unloaded eqpt from Storage USA shed — paid $88 for July rent — Called Jim Walker from QT — set up 2:30 pm mtg at Site — Met GG at Best Western @ ~2:05 pm — went to meet Jim Walker, who introduced us to "Brad", foreman of heavy eqpt. crew. Return to ~~storage~~ shed for K-mart, hdwe store run for batteries, nails, etc. — to Site @ 5:30

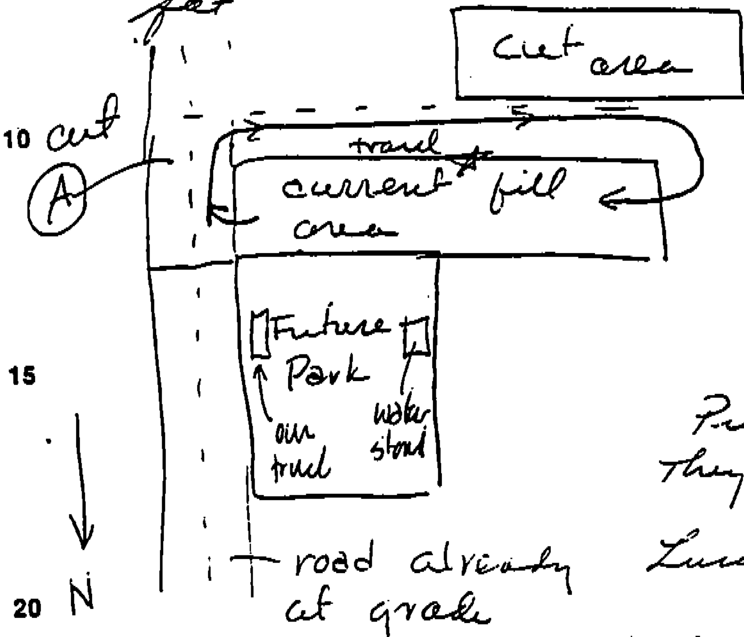
3456- 2

MRI Project No.: **Performed by (name/date):**
Title/Purpose:

Continued from:	**Continued to:**	**Entered by:**	**Verified by:**
Witnessed by:		**Reviewed by:**	**Validated by:**
Witnessed by:			
	(signature/date)	**(initials/date)**	**(initials/date)**

6/20/95 TUESDAY

arr. @ site @ 7:15 am PDT – dropped trailers. Other eqpt from truck, Talked to Brad who told us that plans for tomorrow are to cut new roadway A down ~3½' feet



Decided to put 2 trailers at A to test travel under S winds – could turn around to test unloading for N winds

Put trailer there after they shut down @ 4pm

Lunch @ 11:30 – ½ hr

Went to storage shed to pick up extra generator – went on to collect high-ADT paved road samples. Collected ~~LF~~ Light-duty car/truck fractions @ 3 of 4 sites, totals follow.

Eastern 46/53 LD (2 tons) mean wgt. 3.06 tons

Russell 64/66 2.24

Pecos 139/142 2.17

Geometric mean ratio 93.7%, overall → 2.5 tons

MRI Project No.: **Performed by (name/date):**
Title/Purpose:

Continued from: **Continued to:** **Entered by:** **Verified by:**
Witnessed by: **Reviewed by:** **Validated by:**
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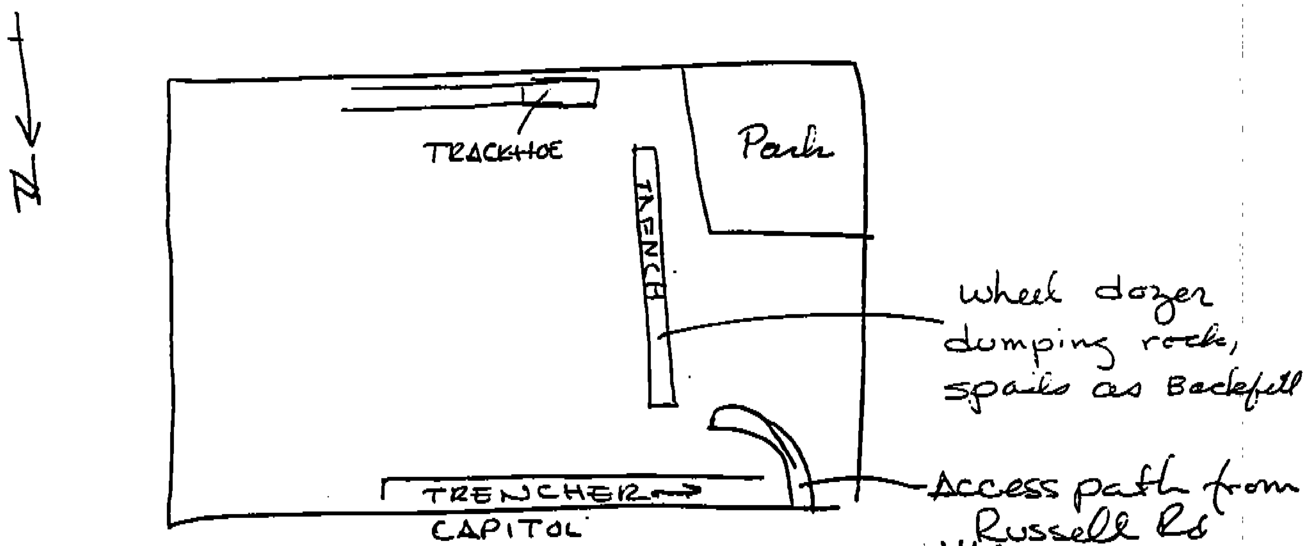
UNIT 1 on 6/19 works 6am to 4pm



NOTE: TRENCHER CLOSE TO ROAD, SO WB traffic on RUSSEL TRAVELS ON UNPAVED SHOULDER TO N

AM 10:15 obs.

1 wheel dozer (FEL)[2] ~~1 load/min~~ GM 6/21/95 1.0 cycle/min ~~3~~ 4 cu yd GM 6/21/95
1 track hoe 2.0 cycle/min 1 cu yd
1 trencher (NEED TO GET CAPACITY FROM BRAD/WALKER)

PM 15:20

2 wheel dozers
1 ~~dump~~, scraping loose mat'l into trench 1.8 cycle/min 4 ~~8~~ cu yd
1 picking up rock & dumping 0.36 cycle/min 2.5 ~~?~~ cu yd

1 track hoe 2.6 cycle/min 1/4 ~~?~~ cu yd
GM 6/21/95

TRENCHER COMPLETED UPON OUR RETURN @ 1520

NO OBSERVED VEHICLES IN/OUT OF AREA ON ACCESS

(* REVISED CAPACITIES FROM TOM WALKER 6/21/95)

MRI Project No.: **Performed by (name/date):**

Title/Purpose:

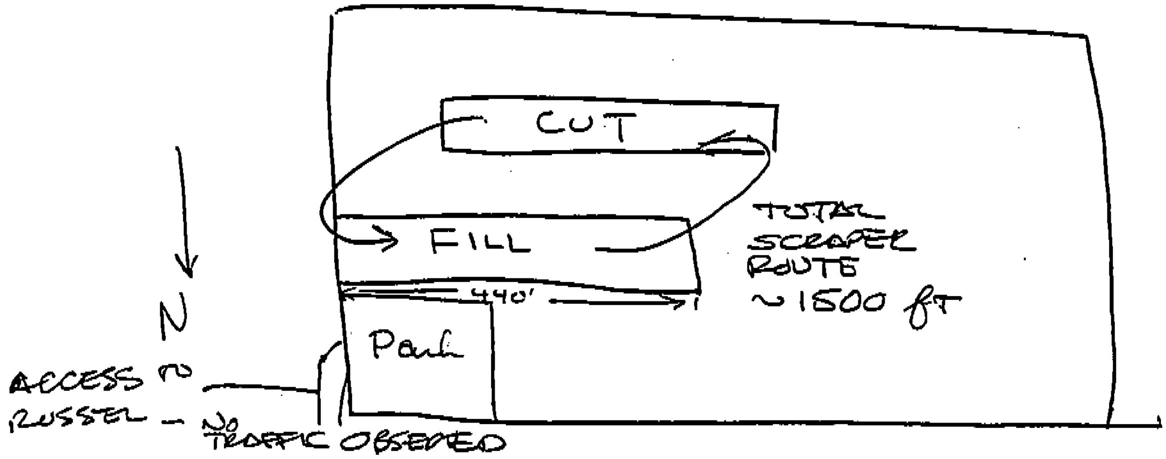
Continued from: **Continued to:** **Entered by:** **Verified by:**

Witnessed by: **Reviewed by:** **Validated by:**

Witnessed by:

(signature/date) (initials/date) (initials/date)

UNIT 2 6/20 WORKS 6am to 4pm



AM — Starting to Break for Lunch during observations

3 scrapers working Clockwise
1 D-9 pushing scrapers
1 water pull
1 vibratory compactor

PM @ 1320

3 scrapers working CCW
0.72 total cycles/min (0.24 per scraper)

1 D-9 pushing scrapers, cleaning up
1 grader cleaning up fill area
moving ~ 3 mph
1 water pull
16 min spreading 4000 gal over ~30' swath
11 min refilling

@ 5 mph × 16 min = 7040 ft @ 30' width
= 23,500 sq yd

4000 gal ⟶ ~0.17 gal/yd² every 27 min

MRI Project No.: **Performed by (name/date):**
Title/Purpose:

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(signature/date) (initials/date) (initials/date)

Wednesday 6/21/95
arrive site 7:15 am
NO LUNCH
lv. site 5:15 pm

Northerly winds upon arrival. Scrapers still working same cut/fill areas as at end of 6/20. About 9:30 am, Brad told us that they would begin cutting road A (see p. 3456-2) and EW road thereafter. <u>However</u>, no more fill would go into area just south of park. This had filled up to grade faster than he expected. Instead, they were supposed to travel over the old fill area back to the new cut. Instead of this route, the scrapers began to travel along southern edge of park area. We moved trailers down to test this route under northerly winds, but queuing of water trucks and scrapers bypassing behind us to avoid water queues convinced us this wouldn't work out as a test site.

Took a break ~ 10:30 and called Will Cates. Told him about problems of testing when there's 5-6 pieces of eqpt in ~5 ac spot.

~11 am, we found out that they were now running back along Oquendo Rd ROW (right of way). Moved 1 trailer and big truck over to this area and set up

MRI Project No.: Performed by (name/date):

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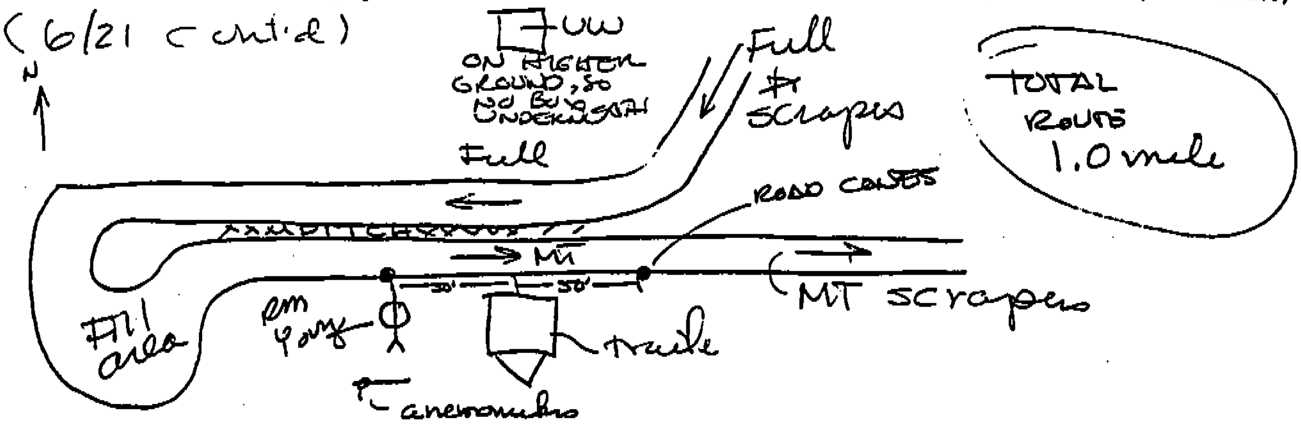
	(signature/date)	(initials/date)	(initials/date)

(6/21 cont'd)



Winds pretty touch and go, mostly w/ S component after we finished set up. Eventually turned to N ~ 1350 and we start Run BA1 @ 1407 (Michelle watch time). Computer/data logger crapped out from temperature shortly after start and we fell back onto Bram (Davis) vanes.

To establish z_0, $u(0.61\,m) = 3.07$ mph (270 fpm)

$u(2.03\,m) = 3.86$ mph (340 fpm)

$$u_* = 0.4 \frac{(3.86 - 3.07)}{\ln 2.03 - \ln .61}$$

$$u_* = 0.263 \text{ mph}$$

$$\ln z_0 = -\frac{0.4 \cdot u_1}{u_*} + \ln z_1$$

$$= \frac{-0.4 \cdot (3.07)}{0.263} + \ln(0.61)$$

$$\ln z_0 = -5.16 \rightarrow z_0 = e^{-5.16}$$

$$= 0.0057\,m$$

$$= 0.57\,cm$$

MRI Project No.: **Performed by (name/date):**
Title/Purpose:

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DAVIS VANES (COULD ONLY RUN 1m value)
ALL TIMES GM'S WATCH

BA1	1408–1413	1010 ft wind run	2.3 mph
	1417–1420	1660 " "	6.3 mph
	1423–1430	4080	6.6
	1432–35	1530	5.8
	1445–1448	1180	4.5

OVERALL 1m w/s = $\frac{9460\ ft}{21\ min}$ = 5.1 mph

w $z_0 = 0.57$cm { 3m w/s = $\frac{u_*}{0.4} \ln(3/0.0057)$ = 6.2 mph
5m w/s = 6.7 mph

$u(1m) = \frac{u_*}{0.4} \ln(1/z_0) \Rightarrow 5.1\ mph = \frac{u_*}{0.4} (\ln[1/0.0057])$
$u_* = 0.395$ mph

BA2 1m 1500–1510 4370 ft ⇒ 5.0 mph (437 fpm)
3m = ~~6.0~~ 6.1 mph
5m = 6.6 mph

STARTED BA2 ~ 1500 — ONLY 2 SCRAPERS WERE RUNNING AFTER 1 BROKE DOWN IN CUT AREA — SEVERE WIND SHIFT TO S AT ~1515

7 good scraper passes
1 bad " " w/ upwind on
2 " " " w/ " off

SHUT DOWN DW SAMPLERS

MRI Project No.: **Performed by (name/date):**

Title/Purpose:

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Witnessed by:			
	(signature/date)	**(initials/date)**	**(initials/date)**

Vehicles timed over 100 ft passage

BΔ1 FULL SCRAPERS. 61.7 sec for 8 vehicles
avg = 13.0 fps = 8.8 mph

EMPTY 52.2 sec for 7 vehicle
avg = 13.4 fps = 9.1 mph

2 Water truck 34.0 sec full, 15.4 empty
avg = 4.05 fps = 2.8 mph

BΔ2 FULL 16.09 sec for 2 passes
avg = 12.4 fps = 8.5 mph

EMPTY 22.27 sec for 4 passes
avg = ~~5.6 fps~~ = 18.0 fps = 12.2 mph

OVERALL AVG SCRAPER SPEED = 9.5 mph

MRI Project No.: **Performed by (name/date):**
Title/Purpose:

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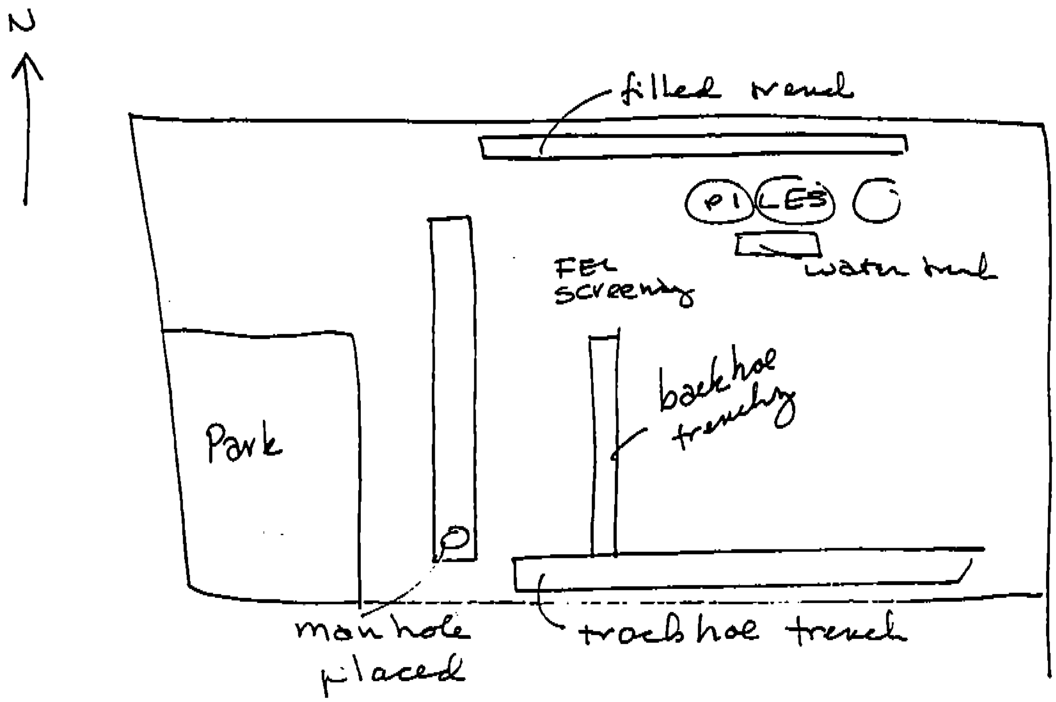
UNIT 1 AM OPERATIONS
6/21/95 (OBSERVED FROM 820 to 855 am)



TRACKHOE 2.7 cycles/min - but only ran 27 of 35 min
∴ 2.1 cycles/min at 0.25 cu yd

WHEEL DOZER (FEL) screening mat'l
0.50 cycle/min but only ran ~~29/35~~ 29 of 35 min
so 0.42 cycles/min at 4 cu yd

Backhoe 0.91 cycles/min but only ran 17/35 min
0.44 cycles/min @ 1/8 cu yd.

WATER TRUCK SPRAYS PILES NOT IN USE
STARTING at 838

MRI Project No.: **Performed by (name/date):**

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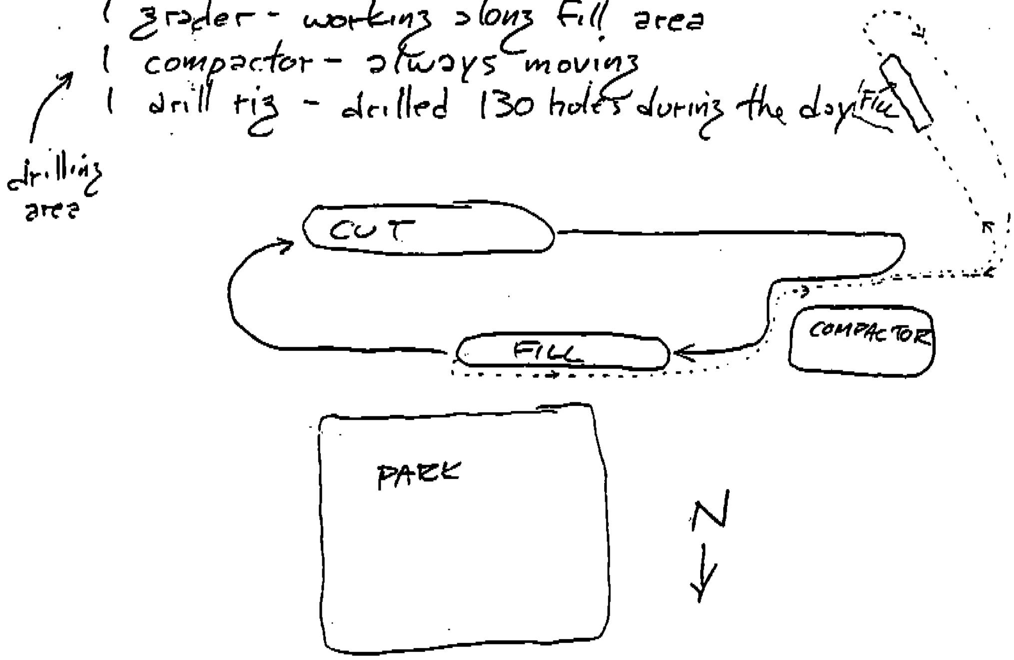
UNIT 2 6/21/95 ~~080~~ 0815-0845

3 scrapers
1 track dozer - working in trench and pushing scrapers
1 water truck - sat from 0815-0833, drove 30 sec, then sat again
1 grader - working along fill area
1 compactor - always moving
1 drill rig - drilled 130 holes during the day



Scraper trip takes ≈4 minutes, but varies as they wait for the dozer.

Twice during period, a scraper picked up rocks from the grader activity and carried them away (dotted line). Round trip takes 5 min.

MRI Project No.: Performed by (name/date):
Title/Purpose:

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Witnessed by:
PM (signature/date) (initials/date) (initials/date)

UNIT 2 6/21/95 — NOT OBSERVED DIRECTLY BUT COULD TELL FROM VEHICLE LOGS FOR BA 1, 2, 3 scrapers until 3 pm when 1 breaks down. Total Loop ~ 1 mile, (as driven after 4 pm)

THURSDAY 6/22/95

on site 7:15
0:45 LUNCH.
GM arr. Santa Ana 5 pm
GG " " " 5:30 pm

Upon arrival, winds very light and variable. GG set up RM Young and strip chart. Left to make phone calls (Crawford, Langston, Don Carlos, Boomer, Julia Lester, Jim Dewey) while GG got hotel rooms in Santa Ana. Winds primarily easterly, for which there is no good spot to set up. By 10 am, stopped running scrapers over the Ozuendo ROW route. Instead, they began working to west of park area. The park area had rec'd water lines, valves and hydrants and ~~then~~ there was a good deal of trenching in area. This would be directly UW of any set up, so we packed truck and drove to Santa Ana.

MRI Project No.:
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FRIDAY JUNE 23/1995
ar site 7:45
Lunch 12:45 to 1:30
Lar hotel 4pm

Met w/ DOUG ALLEN at Sukut Construction site in Newport. Went over their planned activities for next week, but unclear from his discussion and the fact we couldn't see anything in fog, as to what would be best to set up for. Allen will be out monday,* but we met 2nd-in-charge MARK AGUAS. Both seemed very cooperative, offering to blade out areas for trailers, etc. Parked Hino, left traffic counter at entrance, and set off for paved road samples. Resampled high-ADT sites from April visits. ~~Avg non-light-duty~~ Light duty vehicles made up 98% of passes, with avg wgt $\approx 0.98 \times 2 + 0.02 \times 10 = 2.16$ tons

Returned to Newport site to observe scraper operation. Ran 10 push-pulls (both 637's and 657's) in tandem to load. 6 ~~ran~~ ran in ~~a~~ route A (next page) and others ran route B. Thought about more paved road samples, but 55 Fwy traffic backed up so we turned off at next exit. Made calls to Zeldin, Don Carlos, ~~Mitchell~~ Clayton Mitchell, Quill. Main findings/results are

*Also found out site mgr @ other SUKUT is TIM SMITH and Allen or Crawford will advise him of our coming. 2nd site does not work Saturday

MRI Project No.: Performed by (name/date):

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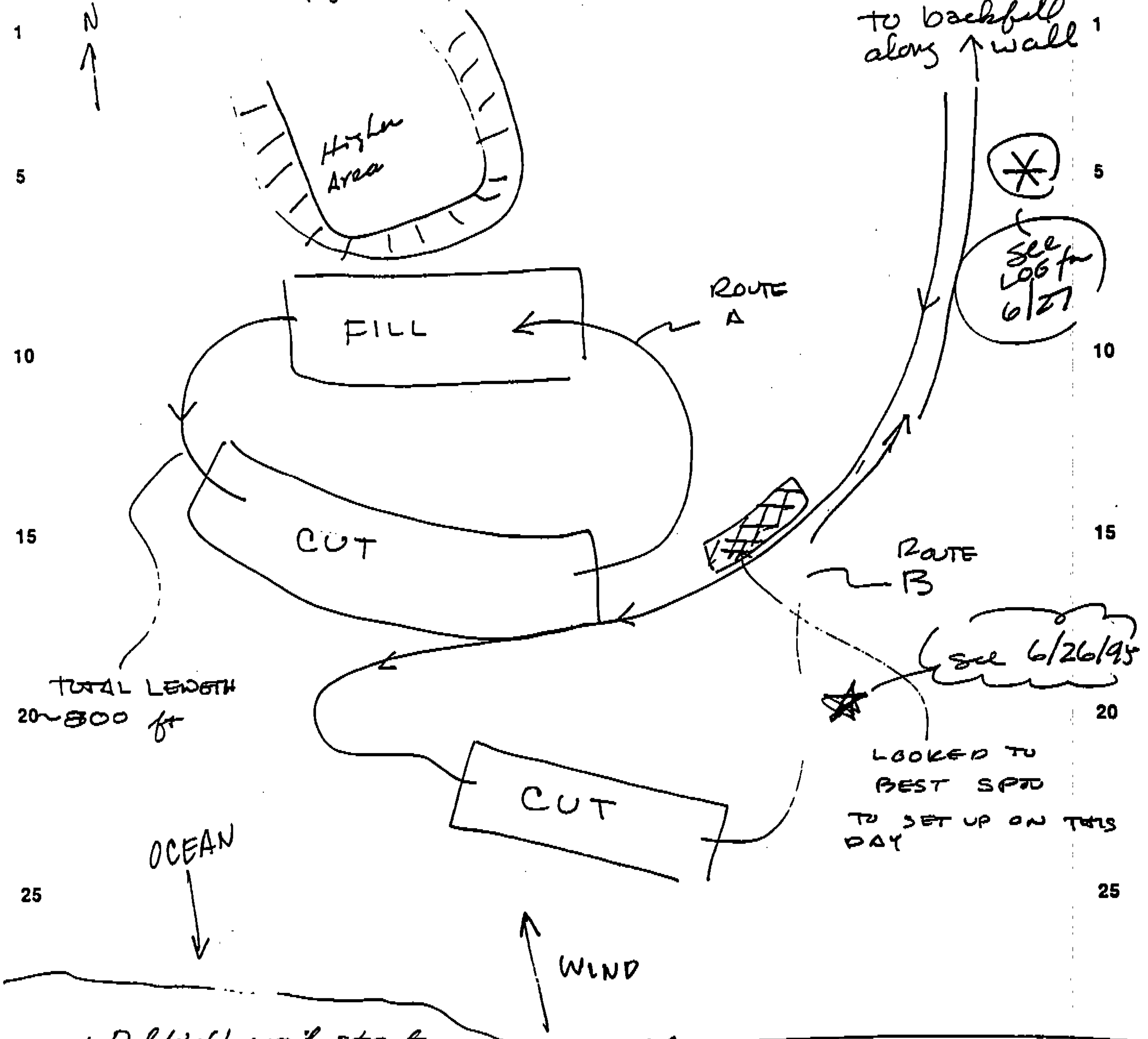

* Del Webb won't start ~~project until after~~ 7/4
* Don Carlos says that his BIA president has been on vacation but will firm up sites early week of 6/26
* Mitchell looking for site near Fountain — other inland area, I told him that latter part of wk of 6/26 would work.

MRI Project No.: **Performed by (name/date):**

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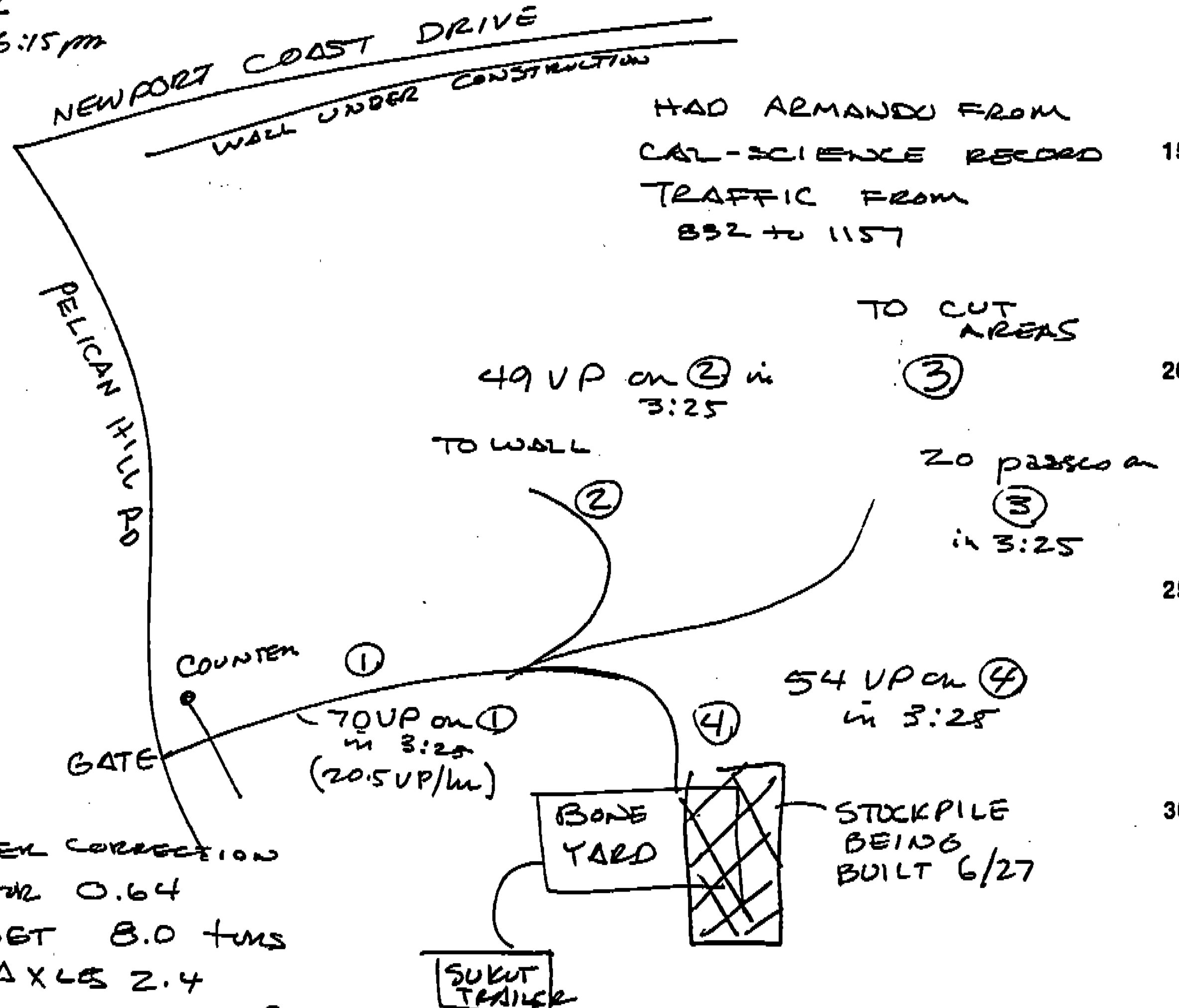
SATURDAY 6/24/95 – lv 8am 1 hr lunch
return to hotel @ 6:15 pm

Collected paved road samples, both low- and high-adt roads, in Anaheim-Orange area and in San Fernando Valley - Both were grids sampled in older SCAQMD study.

MONDAY 6/26/95 – SET UP ROAD IDS FOR TRAFFIC COUNTS AT SITE 3.1 HEAVY FOG AT ARRIVAL

arr site 730
1 hr lunch
lv. SITE 6:15 pm

HAD ARMANDO FROM CAL-SCIENCE RECORD TRAFFIC FROM 832 to 1157



COUNTER CORRECTION FACTOR 0.64
AVG. WGT 8.0 tons
AVG # AXLES 2.4

∴ TAKE COUNTER READING $\times 0.64 \times \frac{2}{2.4}$ = # VEHICLES

MRI Project No.: **Performed by (name/date):**
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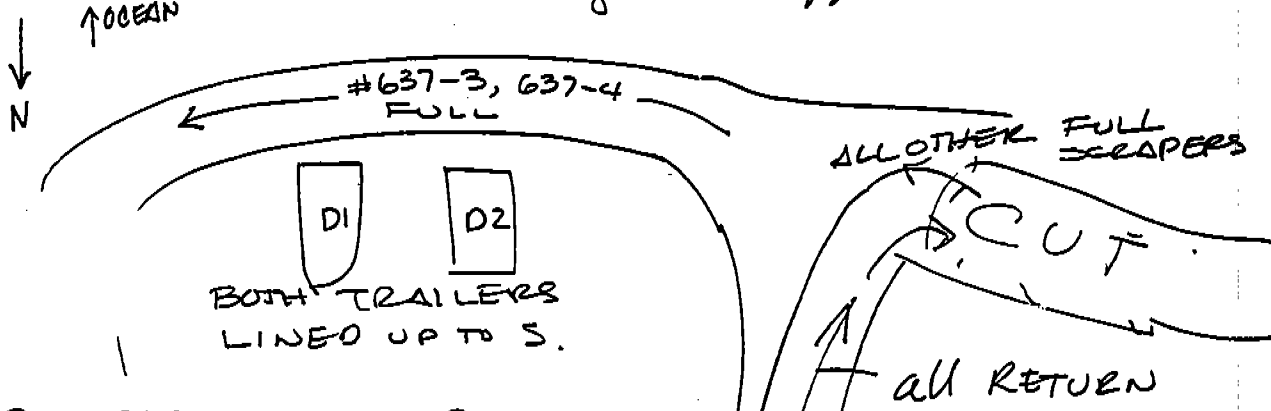
GG/GM set up to test scraper traffic in SE corner of site. Had eqpt set up ~noon and waited for winds to come around and then get traffic.



RAN BA3,4 and then 4. BA5,6. HAD 2 637-CATS DEDICATED TO ~~TRAFI~~ TRAVELING IN FRONT OF US. OTHER 4 SCRAPERS WORKING CUT AND FILL ALONG RETAINING WALL FOLLOWED OTHER ROUTE. COMPUTER/~~B~~INTERFACE AGAIN FAILED, SO FELL BACK ON DAVIS VANES.

Refer to "#" in area map for 6/23/95 in general location of site. In general, part of "Route B" on those pages.

ALSO, ALTHOUGH THEY WORK 7:30 to 6 pm in general, scrapers look to run ~ 8am to 5pm w/ 1/2 lunch

MRI Project No.: Performed by (name/date):

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Witnessed by:		Reviewed by:	Validated by:
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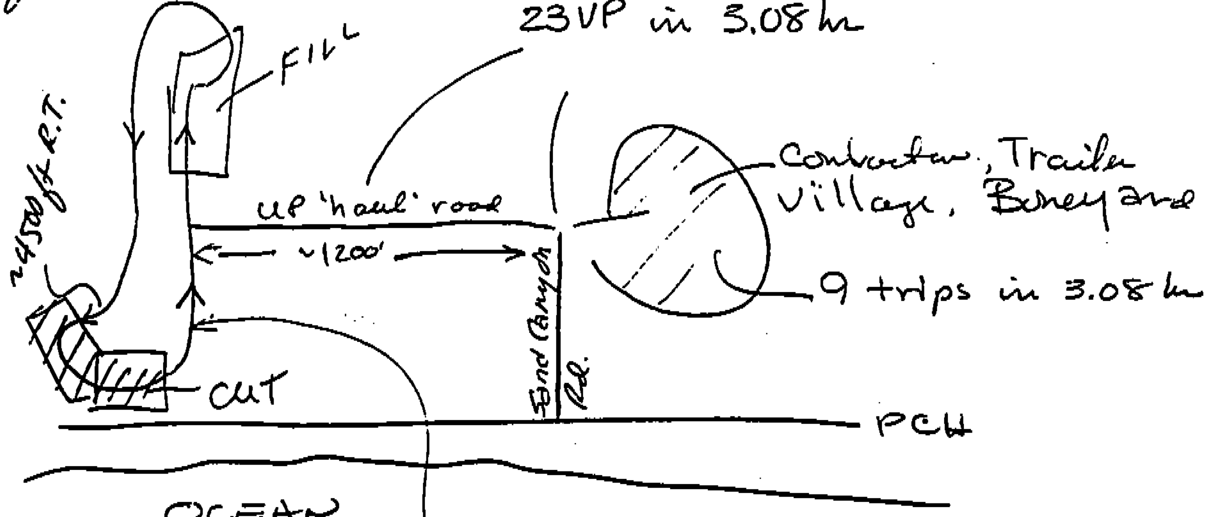
TUESDAY 6/27/95 arr. site 7:45 / lv site 5:15 1 hr lunch

Left Armondo of Cal Science at site 3.2 to record traffic, etc. while GM/GG moved trailer, etc. GM dropped traffic counter at site 3.2. At site 3.2, Jim Smith told me he didn't have a plot plan for the site, so rough sketch follows



SITE 3.2 8 - 657 Cats
1 - D9
1 - D8
1 - 824

0.93 scraper cycles/min all 657 Cats

At site 3.1, GG/GM moved trailers to SE site more conducive to Westerly winds, (See site * on p. 13) — This day had a lot of scraper movement. Started a stockpile to South of Boneyard and had at least 4 657's run all day - See p14

WITH WINDS FROM SW, ONLY NW to SE ROUTES are
#FULL ROUTE IN SE CORNER BUT THIS BETWEEN TWO HILLS (FURROWS)
½ ALONG DUMPING AT WALL, BUT DW SIDE IS OVER THE WALL
*ON 6/27/95, THE CROSS-OVER FROM RD ③ TO ④ WHICH PUTS TRAFFIC ETC AT OUR BACK

MRI Project No.: Performed by (name/date):
Title/Purpose:

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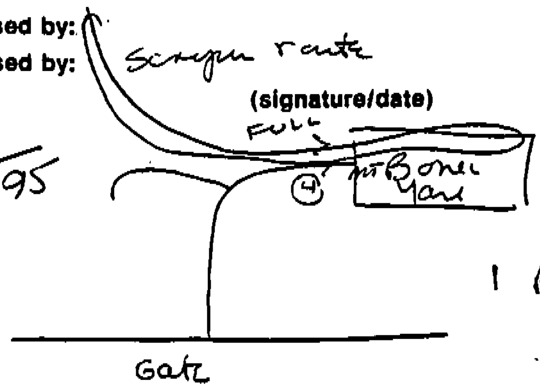
AM
6/27/95



Round Trip distance
2400 ft

1 R.T. takes 3.5 min

WATER TRUCK 16 min cycle — 30 ft swath, 5 mph
4000 gal @16 min → 0.17 gal/yd²
AT LEAST 4 657's run in a.m., joined usually by at least 2 637's and 4 637's at other times. When 637's didn't run this route, they ran in SE corner to bring wall backfill mat'l along east edge of ~~Boon~~ site.

ALSO RAN IN AM 2 FEL's along wall (almost no drop of hgt for dirt, other one used to haul wall blocks), 2 D-9 dozers, and 1 146 grader)

IN PM, 657's ran the AM route but 4-637's ran along back wall area. ROUND TRIP ~2400 ft, 0.67 total cycles/min — SLOWER BECAUSE OF SOME TIGHT TURNS, IN FACT ONE ROUTE INVOLVED A "FIGURE 8" TO TURN AROUND - WATER TRUCK RAN ~ 24 min cycle → 0.11 gal/yd²

NO FEL'S IN PM, BUT STILL RAN 2 D-~~8~~9's, 1 146, and an 824 pulling a grader blade.

WINDS FROM SW WHICH MAINLY MEANT NEITHER OF THE 2 TEST SITES ("★" and "*" on p (3)) would work - Set up BAT at *, ended up as blank run. Collected mat'l, road samples at Site 3.1 and then 3.2

ALSO, HAD VISITOR FROM IRVINE CO. & MATTEKLUND OF SUKUT WHO WONDERED IF WE HAD PERMISSION FROM IRVINE — TOLD THEM THAT WE'D BEEN IN CONTACT W/ CRAWFORD; THEY SAID THEY'D CHECK IT OUT W/ HIM

MRI Project No.: **Performed by (name/date):**
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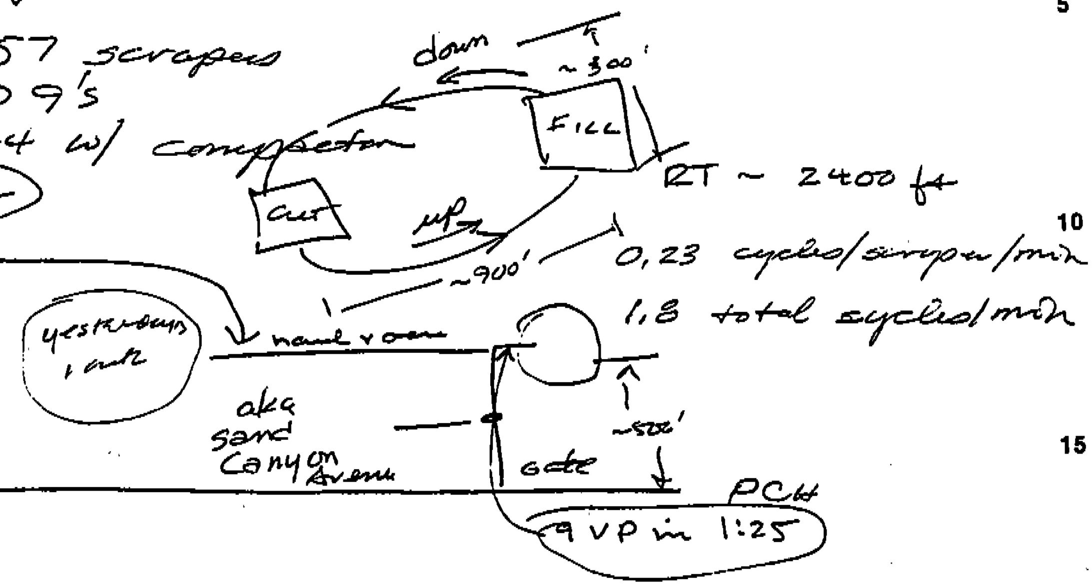
wednesday 6/28/95 — arr 7:45, lunch, left @ ~~1415~~ 1615 (4pm)

SITE 3.2 Left Armando to collect site activity No.s

8 - 657 scrapers
2 - D9's
1 - 824 w/ compactor

17 VP in 1:25



AVG VEHICLE
7.8 tons
6.3 wheels

GG/GM collected remaining paved road sample in Huntington Beach call that we sampled in old SCAQMD Study. Earlier collected paved access road sample @ site 3.2.

No good wind/source orientation available at Site 3.1 - GM advised Will Coates of our plans to stick it out through Friday 6/30. Comments about how sites in SJV were going. GM told him that he had talked with Barbara Don Carlos right before and she told him that we would have addresses/contacts by over the weekend.

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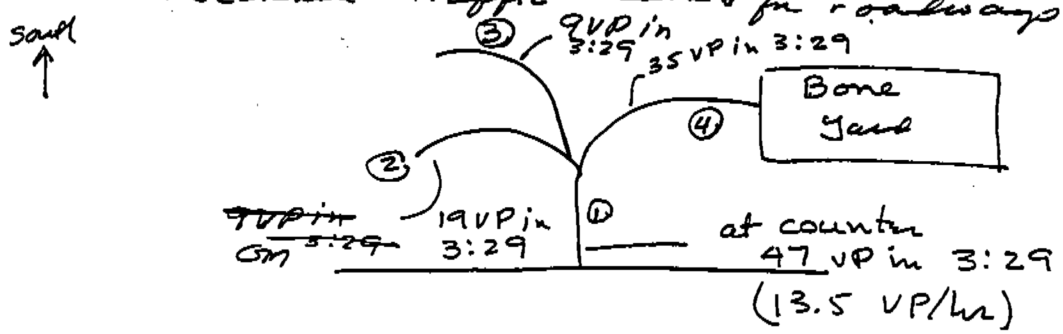
SITE 3.1 AM – NO OBS. FOR SCRAPERS in morning – went to sample paved rd at Site 3.2 & Hunt. Brad Armando recorded traffic data for roadways.



SITE 3.2 PM – Upon return from Lunch, wind/source orientation still bad – had finished stockpiling mat'l near bone yard, and now ~~have~~ moved 637's back toward SE corner. There they had a series of routes, including filling to south of our trailer; delivering fill to Loffel wall area; and some movement of mat'l to highest Lot locations (~#89 & 95 on map). AVG route was ~2400 ft. r.t. and 4 scrapers ~~used~~ (all 637's) ran. Total # cycles/min = 2.6 total cycles/min.

Other Eqpt 2 ~~B~~dozers (D9, D8)
1 824 with compactor
2 Water trucks.
2 FEL ~~at~~ along wall (smoothing dirt - not dropping and delivering Loffel blocks)

GM collected moisture lucky samples over period ~1400 to 1445, but then route changed again.

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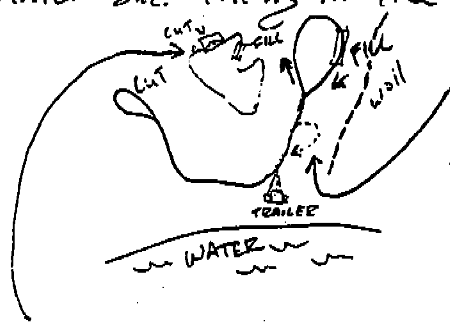
ar site 815
1 hr lunch
lv site 1615

Thursday 6/29/95, Morning.

4 scrapers (637's) were cutting west of the south sampling trailer and filling in the Coffer wall area. 24 round trips were observed in 30 minutes - 5 min per trip. Once in a while, 2 scrapers took an alternate route to fill a different area of the wall. This happened maybe once an hour.



4 other scrapers (657) were running, filling on a buttress. The route was shorter than the 637's were running, but had slower travel speeds due to sharp turns and hills. 24 round trips were also observed in 30 minutes.

Dave Allen asked us to call Michael Crawford. After 2 attempts I got through and he told us that the Irvine Company was "making a stink" about "permits" and our being on-site. He said he thought he had them calmed down, but there was still a question of indemnity. I called and left Dennis Bargie a msg. to fax our insurance info. GG/GM returned to site and met up w/ Armando, whom we had sent to count traffic/cycles at both sites. Went to lunch at noon.

When we returned, Doug Allen told us the ~~[illegible]~~ ("Buck") - a Mr. Buchanan, Irvine's on-site representative - was still pretty vocal wondering who we were and what we're doing - Went to SE corner to observe activities - (also could see op's at site 3.2)

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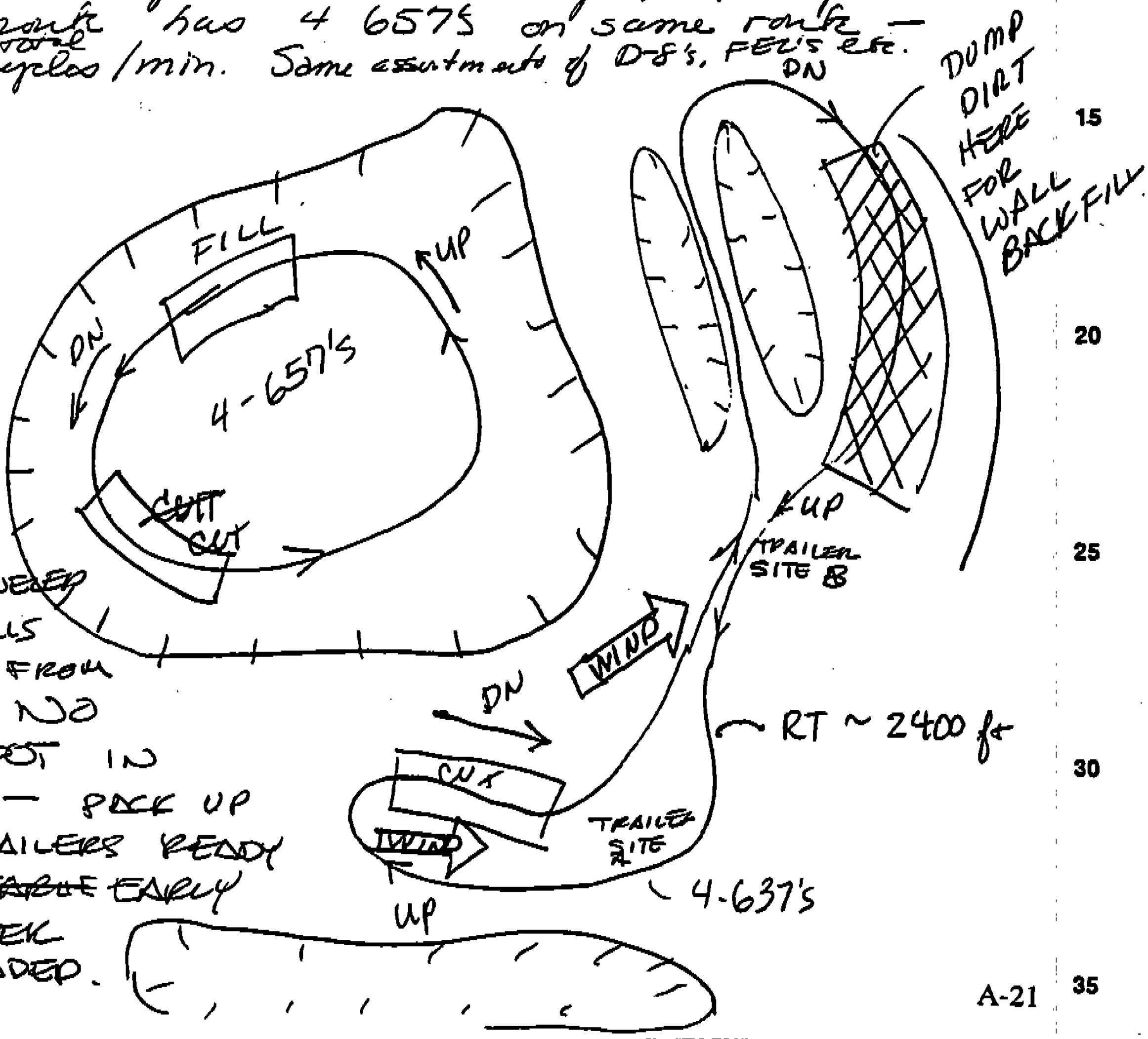
Site 3.2 AM — Same route as on p-18. Armando counted 4 of the 8 657's running. Total of 1.3 total cycles/min. Also 2-D9, and 824 w/compactn.

Site 3.2 PM — 6M obs. from site 3.1 — 6 657's ran @ 3.5 min/cycle. Same as AM route. Also 2 D9's, 824.

Site 3.1 PM — Same basic route as shown on p-20 only exception is that 637's now loop around trailer — 4 scrapers in lower (637) route - 0.65 total cycles/min (0.16 cycle/min/scraper) Upper route has 4 657S on same route — 0.8 total cycles/min. Same assortments of D-8's, FEL's etc.



NOTE - WITH SW WINDS, SITE B HAS $\chi > 450$, BUT WINDS AT SITE 'A' ARE CHANNELED BY PILES, HILLS AND COME FROM W. THUS, NO GOOD SPOT IN THIS AREA — PACK UP AND GOT TRAILERS READY TO MOVE ~~EARLY~~ EARLY FRIDAY AFTER ROADS BLADED.

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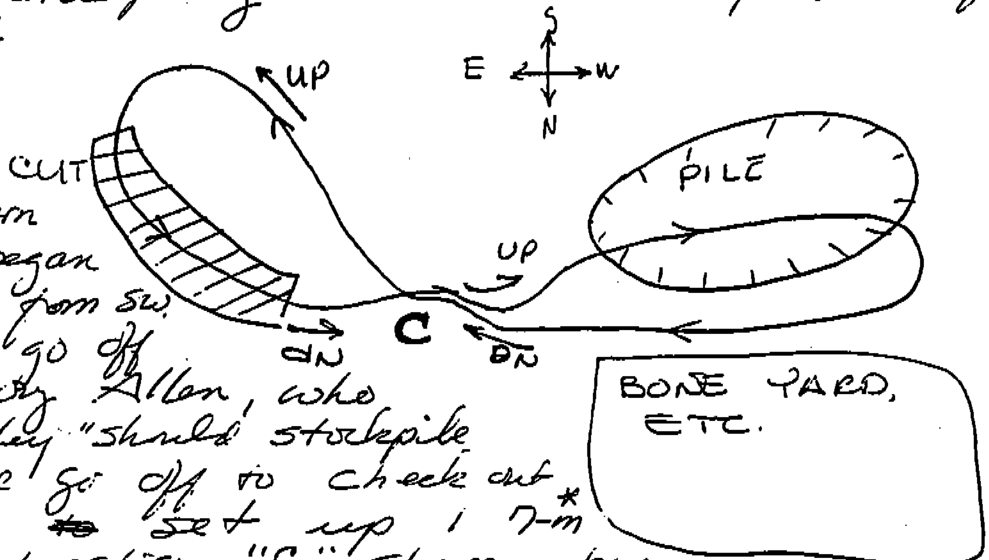
FRIDAY 6/30/95 ARR SITE 7:15 am
1 hr Lunch
EG/GM arrived site early to Lv South Coast, arr B field 7:15pm
move trailers back to Hino and bone yard. Once scrapers, etc move out, they start stockpiling more dirt to pile 5 of bone yard.



watched pattern as winds began to set up from SW. At 9 GM/EG go off to find Doug Allen, who says that they "should" stockpile all day. We go off to check out of hotel and ~~to~~ set up 1 7-m* trailer at Location "C" shown above when we return. Some "comedy of errors", etc., not the least of which occurs when winch gears get stripped. Ran BA8 before lunch, starting approximately 5-10 min after water truck pass. (NOTE - Because of amt of eqpt in operation and difficulty in getting in touch w/ people in charge, opted not to measure water intensity but to get moisture tracking samples instead) - 2 sets of moisture grabs. Shut down when winds started to turn @ ~1130. Took Lunch and set up for BA9 during their lunch break 12:30 to 1pm. Ran BA9 starting about 1:15 ~ At ~1:30, DOUG ALLEN told us that they would stop stockpiling ~2pm. Shut down, broke down trailers, packed and set off for B-field. ←

* Opted ~~for~~ 7m tower because of distance from travel path to nearest safe-set-up pt and because of dense dirt ratio

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SATURDAY 7/1/95 BAKERSFIELD
8am Start
2pm Stop 0:30 lunch

Sampled hi-ADT public roads in B-field. 1st set in industrial/"old town" area. 2nd set in established, up-scale areas around B-field College. Called Rod Langston at lunch - he told me that he had indeed talked with Barbara Don Carlos and they should have sites available this week.

SUNDAY 7/2/95
lv 9:15 DG, GG, GM collected low-ADT
return 2:45 paved road samples in OLD TOWN
1 hr lunch B-field and repeat high-ADT roads from April visit.

Prior to setting out, GM checked voice mail for msg from Barbara Don Carlos. Failing to find any, I called and left msg for Rod Langston to have county commissioner or somebody to call BDC. Upon arrival at La Quinta Inn, RL had left msg ~~@ home~~ to call him at home before Monday 7/3.

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MONDAY 7/3/95

GM flies home. DG installs winch on profiling trailer. DG + GG sweep low ADT roads in North Bakersfield.

TUESDAY 7/4/95 OFF

WEDNESDAY 7/5/95

DG + GG sweep low ADT roads from April visit. Had a meeting with B. Don Carlos in the afternoon. She said there was no commercial construction in the area. She also gave us a map (basically a "New Homes" ad from the newspaper) showing the locations of new subdivisions: We were advised to look at the new home locations, then call B.D.C. to get contact names for sites we might want to work at.

THURSDAY 7/6

GM advises GG + DG to go to Las Vegas to finish road sweeping + demonstration studies there. Leave for Vegas @ 10:00. Arrive 1600.

FRIDAY 7/7 0730-1600 ½ hr lunch

GG/DG meet w/ Tom Walker at Maryland + Pebble site. Tom + 2 others were working on (repairing) the trencher there. He indicated that if the unit was fixed today, they would work tomorrow. They would be trenching + putting in pipe for the next week, if all goes well. The trencher is a "750" model. Tom W. didn't know the capacity, but he said it could move about 250 feet per hour. We'll get more info when we see it in action.

As it turns out, the trencher wasn't repaired today. We visited the site several times, but no one was around. Between site checks, we swept a High ADT sample from roads in established areas of south central Las Vegas, as well as a low ADT sample. We also started the low ADT sample which is a repeat of the April visit.

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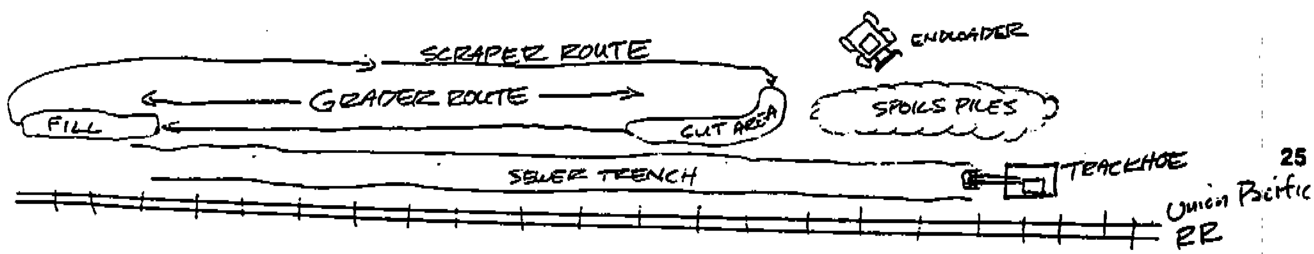
SATURDAY 7/8 0730-1700 no lunch

Completed low ADT repeat sample. Also collected high + low ADT samples from industrial roads. No traffic counts were obtained for the high ADT roads, as it is a weekend. These will be recorded later.

SUNDAY 7/9 OFF

MONDAY 7/10 0600-1600 no lunch

Arrived at Site 1.1 (Golden Triangle) and were escorted by Eric Walker on a site tour. A new railroad track had been installed through the site just south of La Madre running east-west. A sewer trenching was being dug on the north side of the rail track, approx. 12'x12'. The trackhoe (Komatsu PC650LC) was digging to the east, averaging 2 digging cycles per minute. An endloader was attending the trackhoe spoils piles, and sometimes would backfill a little. A scraper (623 E) was taking some of the trenching spoils west along the tracks in a .6 mile round trip. Round trip averaged 4 minutes. A grader (16 G) was constantly smoothing the scraper travel route.



In the NW corner of the site, 2 trackhoes were observed. A CAT EL240B was digging at a rate of 12 cycles in 10 min. toward the west along Washburn Rd. A Samsung SE280 LC was nearby, but this trackhoe was idle in the morning. A small endloader (CAT 950E) was attending the piles.

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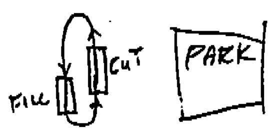
Also in the NW of the site, a Vermeer Trencher (ID numbers of T-85 and 438) was sitting. It was not digging in the morning. A guy who was identified as the operator said it varied as to the ~~&~~ amount of trench he could dig in a given time period. "I can dig 60 ft in 10 hr or 1000 ft in an hour." He didn't have an average rate. The "capacity" of the unit was also unknown.

Near the site entrance, belly dump trucks were bringing in No. 2 material to a stockpile area. Round trip was .3 miles. This material was then taken by a scraper (CAT 623B) down Palmer St. and dumped for a pre-paving road base. Round trip was .8 mile. 10 scraper round trips per hour were observed. 5 belly dump trips and 4 water truck passes were also observed.

A traffic counter was put on the entrance road in the morning, but moved closer to the entrance at noon due to scraper travelling over it. There's not any good place for the hose, as vehicles attack from all angles.

We drove to the Maryland + Pebble site in the morning after observing things at Site 1.1. As before, nothing was happening, so we went to Site 1.2. 3 scrapers (631C) and 1 ~~D~~ D-9 dozer were moving dirt on a north-south route in Unit 2. Scraper round trip took 4 minutes covering 1000 ft route. (21 trips in 30 min). The water truck made 2 round trips during the period. The dozer was pushing scrapers.

RUSSELL



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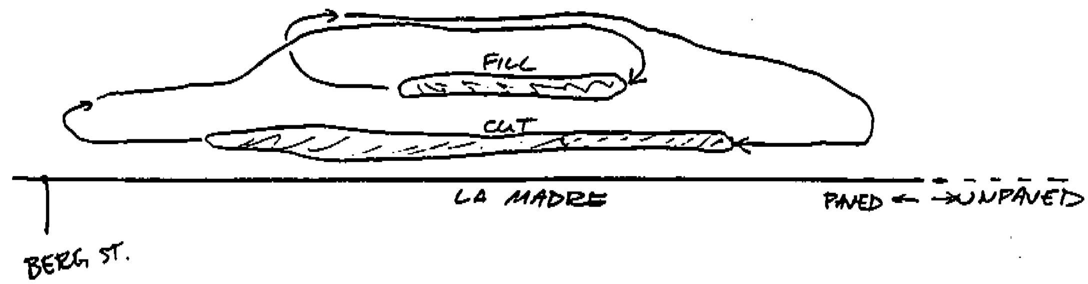
In the afternoon, we revisited site 1.1. Found the trackhoes and trencher in the NW corner idle. The trackhoe and dozer near the RR track were still working, but the scraper and grader had moved west, just north of La Madre (paved part). A round trip for the scraper was .25 miles, taking 4 minutes. A grader (140 G) worked back + forth along the scraper cut.



A traffic count was performed at the site entrance, confirming that belly dump trucks were still bringing mat'l to the stockpile.

Samples taken at Site 1.1 include:

LV-U-004 - P.M. scraper travel route - La Madre
LV-U-005 A.M. scraper travel route - pre paving
LV-U-006 A.M. Scraper travel route - along RR track
LV-M-003 Type 2 material stockpile
LV-M-004 Trackhoe spoils piles

Return to Site 1.2 at 1500 to observe and sample. As before (6/20-21), operations seemed erratic, and no clear pattern could be described. Sample taken was:

LV-U-007 - A.M. scraper travel route

The working hours at Site 1.1 are 0600-1430. Site 1.2 was 6-1600.

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It should be noted that at Site 1.1, the only operation directly performed by Washington Construction (Eric Walker) included the trenching near the railroad, and the scraper travel near the tracks, as well. Southern Nevada was performing the prepaving stuff, and Acme Electric was in charge of the NW corner activities.

All during the day, pickup trucks were travelling throughout the site (site 1.1). No established routes were evident.

TUESDAY 7/11 0600 ~ 1500 no lunch

Arrived at site 1.1 to find a scraper + grader working along La Madre, widening the road on the north side. The grader would pass, leaving a row for the scraper to pick up. The scraper was travelling about ½ mile round trip in 5 minutes, stopping occasionally as the grader got out of its way.

The trench being dug by the RR was continuing, with the trackhoe cycling ≈ 12 times in ten minutes. The bucket size on the trackhoe is 1 cu. yd.

Also observed in the morning ~~was~~ were the pre paving activities in the southern part of the site. Belly dump trucks brought in the road base material, which was then taken by a scraper to the active area. The scraper route today was much shorter than yesterday, approx. 100 yds round trip. The active area was about where State Ave would intersect Palmer. A grader was smoothing the stockpile, and an endloader was working where the scraper dumped. 6 scraper cycles per hour, 8 water truck passes / hour, and 4 belly dump deliveries / hour would be a good estimate of morning activity.

3 water trucks are on site - 1 - 3,500 and 2 - 6,500 gallon. All are running continuously, as today is quite windy. Each truck is seen returning to the water tank every 20 min;

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taking 5 min to fill. The Z-6,500's seem to be watering everywhere, while the 3,500 concentrates on the road base stockpile area.

To get a handle on the miscellaneous traffic on site, the map in the test plan (Fig. 2) was traced onto quadrille paper, effectively making a grid. Vehicles were recorded as to their starting point, stopping point, and wheel/axle config. This observation was performed for an hour in the morning. 36 vehicle trips to various spots were noted.

A couple delivery routes were discovered today that did not occur yesterday. 5/18 dump trucks brought material on site from the corner of La Madre and State. 4 round trips per hour were seen, with 3 different dump sites. The material delivered was not handled after dumping. The delivery routes can be obtained from the data described in the paragraph above.

Traffic mixes were obtained from the high ADT industrial roads sampled Saturday 7/8.

In the afternoon, the RR side trench was still being dug at the same rate as before. By the end of the day, the trench was 75 yds longer to the east than yesterday. The scraper and grader were still working along La Madre as before.

The prepaving activities had changed little from this morning. The main difference being the length of the scraper route, now 300 yds, as the active area moves to the north. 6 scraper cycles per hour is still reasonable, but the frequency of the belly dump deliveries is down to 2/hour.

No effort was made to return to Site 1.2 or 1.3, as the 2 hour round trip (traffic jam) seemed better spent at Site 1.1.

Samples collected today include:
LV-U-008 - Travel routes throughout site 1.1.

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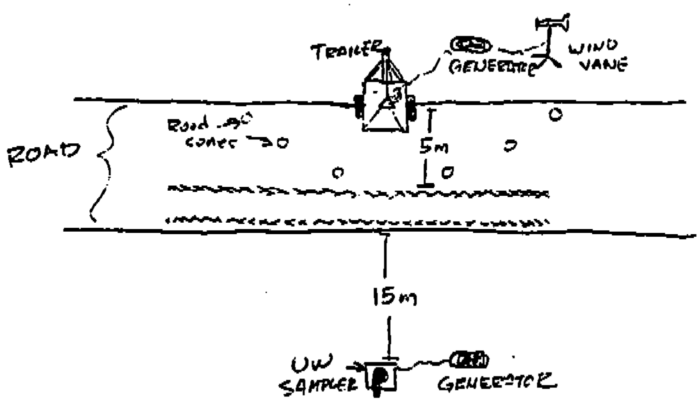
WEDNESDAY 7/12 0600-1500 DG, 0600-1600 GG

High ADT sample was taken from roads sampled in April. Pulled traffic counter at site 1.1, and left Vegas for Palm Springs at 10:00.

THURSDAY 7/13 0700-1700

Arrived at Site 2.1 (Del Webb Palm Springs) and checked in at 38[th] Ave. security gate. The security person called Paul Quill, who sent Dwight Kelley to show us what was happening. The road base delivery that was expected ~~to be delivered~~ had already been finished yesterday at Tract 27365. Grading and compacting is expected to last a week and a half, then paving will begin. Sewer trenching is occurring in the northern tract. In the north, an unpaved road connects some active construction areas. This road has several long stretches between curves, and appears to be tractable for source testing at several wind directions.

Wind vane was set up at several locations on this road, trying to find a location where testing was possible. An East-West section of road was chosen for setup, since South winds were the strongest. Here's a picture.



Upwind sampler started at 1318.
BA 10 started at 1343. Davis vanes at 1m and 3m were used to determine wind speed. 30 captive pickup passes and 2 medium duty truck passes comprised this run. Captive passes were at 25 MPH

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BA10 ended at 1412. The upwind sampler was found off at 1417. The generator was running (it was the little Honda), but no electrons were flowing down the extension cord. A circuit breaker failure (or perhaps success) was found responsible, but for some reason the breaker could not be reset. A large Honda was then used for the upwind, and it was restarted at 1446.

BA-11 started at 1451. Traffic began at 1458, since winds went bad for a few minutes after the samplers were started. The trailer was turned 10° to the East at 1512. Traffic stopped at 1525, after 29 captive passes (at 25 mph.) DW samplers shut off at 1526.

BA12 began at 1553. The trailer was turned 10° to the East at start, then moved back to 0° at 1609. The run ended at 1621 after 30 captive passes (25 mph) and 1 medium duty pass.

Captive traffic was not continuous during the runs today. Winds frequently changed for several ~~m~~ minutes, requiring traffic to cease until the wind came back. Despite the start-stop nature of the traffic, winds were good for periods of 5-10 minutes at a stretch and many passes could be obtained during those times.

Road Sample taken:

CV-U-001 - Post BA-12, 11½' x10".

Temperature today was 105°F during sampling. Heat stress was evident in both crew members, and any unintelligible verbage or spelling errors in this log are directly related to said affliction.

FRIDAY 7/14/95 0700-1500 no lunch

Trailer + other equipment used yesterday were dismantled and packed in truck. Blanks were taken (BA-13).

Lots of activity today. In Tract 27365, a scraper (613C), grader (#12G), small roller, and 3000 gal water truck were smoothing + rolling the roads. The scraper picked up the row made by the grader and carried it to road sections that hadn't been graded yet. The route varied, as

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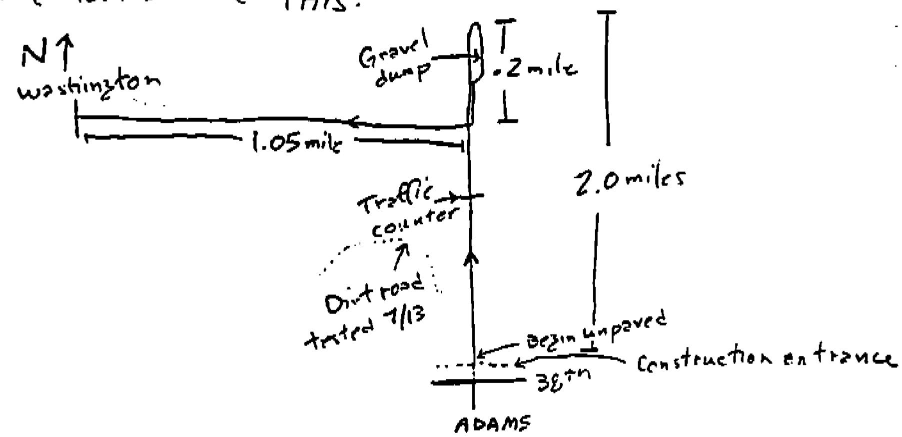
the operation progressed, but a typical round trip by the scraper was .6 miles over 9 minutes. The water truck emptied in 17 minutes. This operation occurred all day.

In the north, the sewer trenching also went on all day. The EL240B trackhoe (1cu.yd bucket) made 3 cycles per minute, digging a trench ≈ 20'x20'. This sewer line is being dug approximately north-south, and it appears that if Grand Oaks Ave continued north, the sewer would run next to it.

Also in the north - A road project is going on where 5/18 trucks bring a gravel material and dump it, followed by grading. The road being built runs to a tank farm hidden in the hills. A traffic counter was placed on this haul road. The route looks like this:



The gravel trucks entered at 38th + Adams, drove 3.25 miles on unpaved roads, then exited on Washington. The water truck on this route sprayed the north-south road most of the time, and rarely hit the east-west road.

It was learned that the contractor hauling gravel + trenching will work tomorrow (Saturday), but the one prepping the roads in Tract 27365 will not work. We shall see.

Little Honda generator worked fine today. Weird.

Samples taken today include:

CV-M-001 - Trenching spoils from sewer trench - Grand Oaks Ave.
CV-U-002 - Gravel haul ~~road~~ route in north
CV-U-003 - Prepaved roads in Tract 27365

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SATURDAY 7/15/95 0700-1630 ½ hr lunch

Well, nobody at Del Webb was working today. The construction entrance gate was closed in the morning, and was closed when we checked throughout the day. We also checked the Century Homes site (Site 2.2), but they too were inactive.

Paved road samples were taken, including:

High ADT in Palm Springs - repeat of April
Low ADT " " " " "
High ADT - City of Coachella
Low ADT - " " "

SUNDAY 7/16/95 1130-1530 no lunch

After a short rain delay in the morning, High + Low ADT samples were taken in Palm Desert. No traffic counts were taken for the High ADT roads - they will be completed during the week.

MONDAY 7/17/95 0600-1400 no lunch

Went to Century Homes (Site 2.2) first thing to put down traffic counters. Got ahold of Dennis Cunningham to let him know we were there. Not much was going on at the site, just some yard work and interior finishing. Bud at the site said no trenching would occur for at least a week. All vehicles entering the site were 2/4 cars and pickups, the majority of which entered from Miles on Bridgette. About ¼ of the vehicles entered from the south on Desert Air. ~~("Entering" includes~~ The main travel route was Bridgette to Cara, with some vehicles heading to the trailer. See the map on the next page.

At Del Webb, the construction gate was closed again. The gravel hauling seems to have ended, as no trucks were seen all day. Traffic counter confirmed that no activity like that which occurred on Friday was going on today. The traffic on this road consisted of pickups going to the tank

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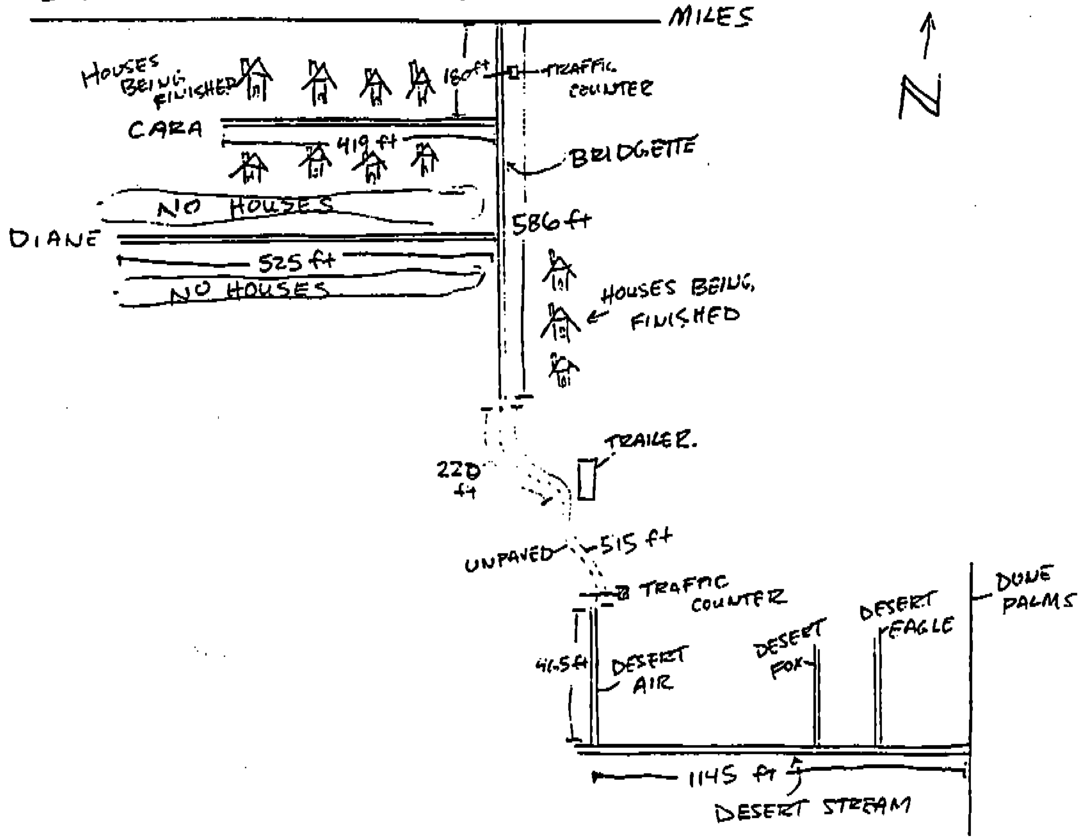
Site 2.2 (not to scale)



farm in the hills and water truck passes.

The sewer trenching in the north went on all day. The trackhoe was still cycling at 3 scoops per minute. An endloader (966E) was knocking ~~b~~ down the spoils piles into the trench, covering the pipe which had been installed. It was dumping or pushing 3 times per minute for 30 minutes, then it went into the trench and smoothed the dirt it had just put in for 30 minutes. The smoothing travel cycle took 30 seconds; 100 ft driving backwards, then 100 ft forward. The endloader filled about 100 ft of trench per hour.

In tract 27365, the scraper, grader, roller, water truck continued ~~them~~ work on the roads. Routes varied, but all equipment is constantly moving.

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Witnessed by:

Continued to:

(signature/date)

Entered by:
Reviewed by:

(initials/date)

Verified by:
Validated by:

(initials/date)

Traffic counts at the High ADT paved roads sampled Sunday were taken.

Samples taken today:

Paved road - Bridgette 100' south of Miles - Site 2.2
CV-U-004 - Unpaved travel areas - Site 2.2

TUESDAY 7/18/95

At Site 2.2, the same activities were occurring. Traffic counters were "calibrated" in the morning and again in the afternoon. Samples taken today:

Paved road - Desert Air 150' South of const. entrance
Paved road - Adams (Site 2.1) 50 yd south of 38th Ave.

WEDNESDAY 7/19/95

DG goes to Las Vegas for cooling towers + to return pickup. GG begins drive home.

Monday July 31, 1995 (CDT) (PDT)

GM leaves home 5am for 7am flight to Fresno. Arrive Fresno ~10:30 am, got van and called Rod Langston to set up 1 pm meeting. Met at 1 pm @ 1999 Toulene (sp) and retrieved eqpt that had been shipped. Met @ 2pm with BOB GREENWAY of McCarthy Construction at Site 5.1 – Valley Childrens Hospital at Avenue 10 and Road 40½. Greenway said that before we can get on-site that we needed OK from Jeff Green from McCarthy in Sacramento. I called and left msg. ~4:30pm w/ Dennis Barger to call Green and send insurance info. Dropped traffic counter on access road.

Traveled to other site, @ Alluvial and Blackstone – TRACEY BENNET of Crawford Construction wasn't there so we went to their offices in Clovis. There, Bennet said that there wasn't any problem to using this as Site 5.2.

Returned to District office, ~5pm. went to KMart that evening for supplies.

Tuesday August 1 1995

arr S:k52 @ 7:15 am. Some question from Forest City Company rep, who wanted to make sure with Tracy Bennet. I started to drop counter at access point. Got OK to start up but found counter battery dead. Bought new battery and rope to string tube across road. NOTE - ROAD is wider than tube, but all traffic enters/exits from one corner, so I tied 2 tubes together to span paved road.

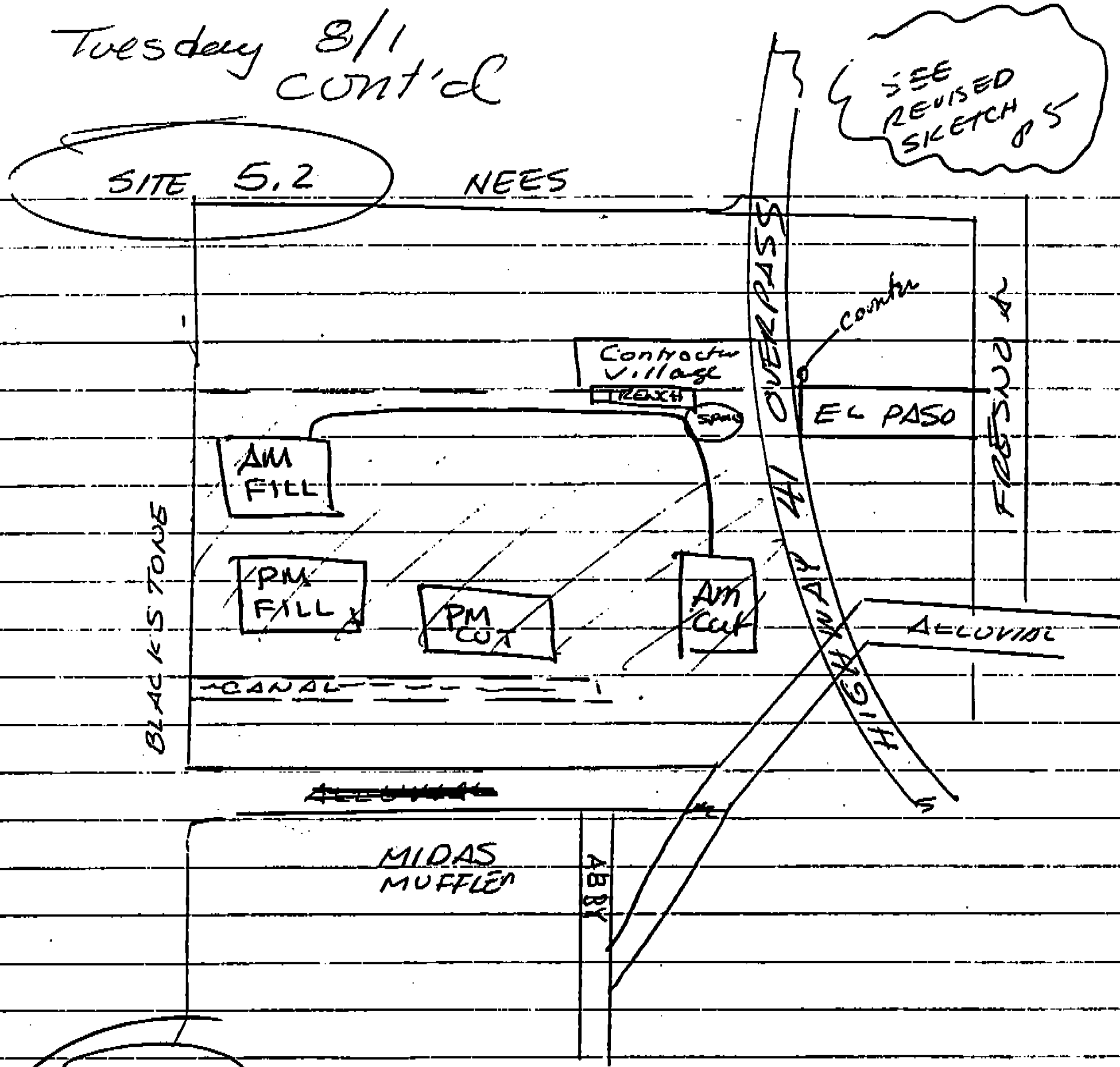
DID AM OBS at 5.2 - went to 5.1 ~ 10:15 am - Checked with Greenway who said he hadn't heard from Green in Sacramento. I took a "calibration" count for the pneumatic counter and then went to check up on Barger (I had called from hotel @ 6:15 am PDT). Still no answer, so I called switchboard. They checked w/ Contracts who said DB out until Thursday - had them give me Jeanette Tombaugh's extension so I could get hold of her after her lunch hour - Remote counts not feasible because most operations were below grade and can't be seen from access road.

(plus unpaved road sample)

623-2vehicles in 9:59 3:46 vehicles/hr

Tuesday 8/1
cont'd

SEE REVISED SKETCH p 5



AM

623 - 2 cycles in 4:57 - 0.4 cycle/min
613 - 2 cycles in 5:12 - 0.37 cycle/min

1 - 613C Scraper } each 4.5 min/cycle → TOTAL 0.4 cycle/min — 4000 ft Round Trip
1 - 623B " }

JOHN DEERE 992 DLC trackhoe, ½ yd bucket
10 cycles in 6:20 → 0.8 yd³/min

1 - Cat 146 grader
1 - Compactor (Rex)
1 - Water Truck

PM Same Eqpt as AM
plus Cat 950 FEL
2nd Water Truck

Trackhoe 1.8 cycles/min → 0.9 yd³/min
Scrapers — 0.8 cycles/min → ~~TOTAL~~ 1100 ft Round Trip

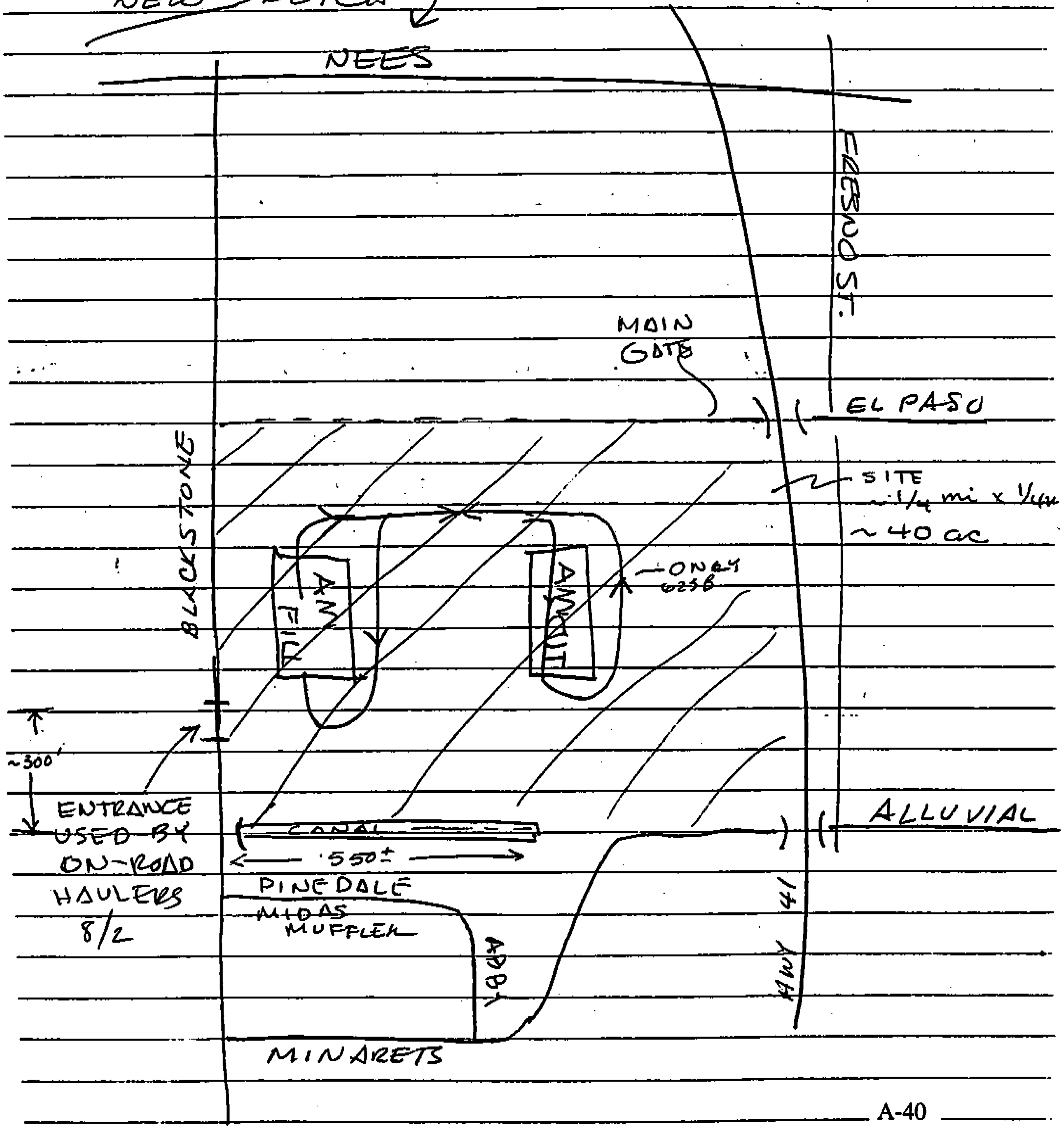
Tuesday 8/1 Cont'd

Called Jeanette @ 11:10 am and had her call Jeff Green and fax him what he needed. Went to lunch @ 11:30 through 12:30. Returned to Site 5.2 for PM OBS. Conducted 2nd calibration count - Because FEL was backfilling trenched mat'l, I went ahead and grabbed a sample of the trackhoe spoils. Completed 5.2 observations and went back to 5.1 to see if we had OK. Talked to Greenaway @ ~2:15pm who said he hadn't heard anything and would call Green - I went to pay phone to check up w/ Jeanette - she had also left msg - I asked her to see if he calls back and if not to fax the old insurance info that DB had sent SUKUT in June, and to leave me a voice-mail* at end of day.

Returned to Site 5.2 @ 15:20 to check ~~ob~~ activities and get mat'l samples. They had shut down scraping and parked eqpt. I got scraper route, scraper mat'l and FEL travel surface samples. Left site @ 16:30, bought this notebook and returned to hotel.

* Jeanette was not able to reach Green, but left a 3rd msg and said it was urgent

Wednesday August 2, 1995 arr site 5.2
Site 5.2 7:15 am
Water Truck takes ~3 min to fill
NEW SKETCH



WEDNESDAY 8/2/95
CONT'D

AM

ONLY 623B Scraper ran, 613C idle
4 min/cycle with 1 min spent in loading
route 2500' ± ROUND TRIP

A250 14 G Grader
950E FEL
JD Trackhoe 28.4 sec/cycle → 2.1 cycles/min
Water Truck
Compactor

A250 BROUGHT IN SAND IN
5/18 TANDEM BELLY DUMPS
(TOTAL OF 12 yd / load)

22 Loads/hr
total travel distance ~1700' ±
SUBSTANTIAL TRACKOUT ONTO BLACKSTONE

Continued quest of the elusive Jeff Green
Jeanette Thombaugh told me that she hadn't heard - I called Langston 3 times, but never got through - Called Bob Greenway who said Green was in Monterey today - This meant that site 5.1 wasn't going to happen so I put together a written note to leave w/ Langston @ 1999 Toulemne
He was available when I got downtown so I told him what I put in the note.
Left 1999 Toulemne @ ~12:30 — went to pull counter @ site 5.1 ~~and change~~ returned to site 5.2 - pulled counter there and pm obs, and get truck road sample

~~PM~~ OBS

SAME TRUCK ROUTE 30 LOADS/hr
1700' R.Trip.

BOTH SCRAPERS IDLE
FEL 950E running
J.D. Trackhoe 17.4 sec/cycle → 3.4 cycles/min
14 G Grader
Compactor
Water Truck

Packed up eqpt — sent out Fed Ex and return to hotel @ 4pm

Appendix B

Site Inventories

Site Inventories

The following pages present the emission inventories which serve as the basis for recommending new construction emission factors. The estimated emissions represent uncontrolled conditions and the estimates are based on the factors given in Table 1 of the report.

Note that the scraper removing topsoil factor of 20.2 lb/VMT in Table 1 has been used under an assumption that scrapers average 250 ft in the removal process.

Site 1.1 7/10/95 AM

Material Handling

	Silt %	Moisture %	Amount Handled (ton/hr)	PM10 Emission Factor (lb/ton)	PM10 Emission Rate (lb/hr)
Trackhoe	5.85	14.92	244	0.000159	0.0388
Scraper removing	5.85	14.92	15[a]	0.96[b]	14.4
Scraper unloading	5.85	14.92	483	0.04	19.3
Scraper removing	5.97	5.13	10[a]	0.96[b]	9.6
Scraper unloading	5.97	5.13	308	0.04	12.3
Truckdump	5.97	5.13	110	0.000710	0.0781
Total					55.7

Vehicle Travel - unpaved

	Silt %	Moisture %	Speed (mph)	Weight (ton)	Number of Wheels	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Endloader	6.67	6.02	3.0	23	4	3.0	0.486	1.46
Scraper	6.67	6.02	15	53	4	9.0	1.08	9.72
Grader	6.67	6.02	3.0	30	4	3.0	0.279	0.837
Truck	16.52	1.12	15	33	18	1.5	16.4	24.6
Scraper	3.48	1.09	15	51	4	8.0	0.979	7.83
Light duty	16.52	1.12	15	2.0	4	8.0	1.09	8.72
Med. duty	16.52	1.12	15	5.0	6	3.2	2.53	8.10
Total								61.3

[a] Cycles/hr.
[b] Lb/cycle.

Site 1.1 7/10/95 PM

Material Handling

	Silt %	Moisture %	Amount Handled (ton/hr)	PM10 Emission Factor (lb/ton)	PM10 Emission Rate (lb/hr)
Trackhoe	5.85	14.92	168	0.000159	0.0267
Scraper removing	9.99	4.20	15[a]	0.96[b]	14.4
Scraper unloading	9.99	4.20	483	0.04	19.3
Scraper removing	5.97	5.13	10[a]	0.96[b]	9.6
Scraper unloading	5.97	5.13	308	0.04	12.3
Truckdump	5.97	5.13	110	0.000710	0.0781
Total					55.7

Vehicle Travel - unpaved

	Silt %	Moisture %	Speed (mph)	Weight (ton)	Number of Wheels	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Endloader	6.67	6.02	3.0	23	4	3.0	0.486	1.46
Scraper	9.99	4.20	15	53	4	3.8	1.90	7.22
Grader	9.99	4.20	3.0	17	4	3.0	0.279	0.837
Truck	16.52	1.12	15	33	18	1.5	16.4	24.6
Scraper	3.48	1.09	15	51	4	8.0	0.979	7.83
Light duty	16.52	1.12	15	2.0	4	8.0	1.09	8.72
Med. duty	16.52	1.12	15	5.0	6	3.2	2.53	8.10
Total								58.8

[a] Cycles/hr.
[b] Lb/cycle.

Site 1.1 7/11/95 AM

Material Handling

	Silt %	Moisture %	Amount Handled (ton/hr)	PM10 Emission Factor (lb/ton)	PM10 Emission Rate (lb/hr)
Trackhoe	5.85	14.92	101	0.000159	0.0161
Scraper removing	9.99	4.20	12[a]	0.96[b]	11.5
Scraper unloading	9.99	4.20	386	0.04	15.4
Scraper removing	5.97	5.13	6[a]	0.96[b]	5.76
Scraper unloading	5.97	5.13	193	0.04	7.72
Truckdump	5.97	5.13	88	0.000710	0.0625
Total					40.4

Vehicle Travel - unpaved

	Silt %	Moisture %	Speed (mph)	Weight (ton)	Number of Wheels	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Endloader	6.67	6.02	3.0	23	4	3.0	0.486	1.46
Scraper	9.99	4.20	15	53	4	6.0	1.90	11.4
Grader	9.99	4.20	3.0	30	4	3.0	0.279	0.837
Truck	16.52	1.12	15	33	18	1.2	16.4	19.7
Scraper	3.48	1.09	15	51	4	0.34	0.979	0.333
Light duty	16.52	1.12	15	2.0	4	8.0	1.09	8.72
Med. duty	16.52	1.12	15	5.0	6	3.2	2.53	8.10
Hvy. duty	16.52	1.12	15	33	18	3.6	16.4	59.0
Total								110

[a] Cycles/hr.
[b] Lb/cycle.

Site 1.1 7/11/95 PM

Material Handling

	Silt %	Moisture %	Amount Handled (ton/hr)	PM10 Emission Factor (lb/ton)	PM10 Emission Rate (lb/hr)
Trackhoe	5.85	14.92	101	0.000159	0.0161
Scraper removing	9.99	4.20	12[a]	0.96[b]	11.5
Scraper unloading	9.99	4.20	386	0.04	15.4
Scraper removing	5.97	5.13	6[a]	0.96[b]	5.76
Scraper unloading	5.97	5.13	193	0.04	7.72
Truckdump	5.97	5.13	44	0.000710	0.0312
Total					40.4

Vehicle Travel - unpaved

	Silt %	Moisture %	Speed (mph)	Weight (ton)	Number of Wheels	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Endloader	6.67	6.02	3.0	23	4	3.0	0.486	1.46
Scraper	9.99	4.20	15	53	4	6.0	1.90	11.4
Grader	9.99	4.20	3.0	30	4	3.0	0.279	0.837
Truck	16.52	1.12	15	33	18	0.6	16.4	9.84
Scraper	3.48	1.09	15	51	4	1.0	0.979	0.979
Light duty	16.52	1.12	15	2.0	4	8.0	1.09	8.72
Med. duty	16.52	1.12	15	5.0	6	3.2	2.53	8.10
Total								41.3

[a] Cycles/hr.
[b] Lb/cycle.

Site 1.2 6/20/95 AM

Material Handling

	Silt %	Moisture %	Amount Handled (ton/hr)	PM10 Emission Factor (lb/ton)	PM10 Emission Rate (lb/hr)
Endloader	3.40	1.35	336	0.00460	1.55
Trackhoe	3.86	1.39	42	0.00442	0.186
Scraper removing	3.63	1.37	45[a]	0.96[b]	43.2
Scraper unloading	3.63	1.37	1890	0.04	75.6
Dozer	3.63	1.37			3.34
Compactor	3.63	1.37			3.34
Total					127

Vehicle Travel - unpaved

	Silt %	Moisture %	Speed (mph)	Weight (ton)	Number of Wheels	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Endloader	5.62	0.56	3.0	23	4	3.0	0.41	1.23
Scraper	7.69	1.16	15	61	4	12.8	1.87	23.9
Total								25.1

[a] Cycles/hr.
[b] Lb/cycle.

Site 1.2 6/20/95 PM

Material Handling

	Silt %	Moisture %	Amount Handled (ton/hr)	PM10 Emission Factor (lb/ton)	PM10 Emission Rate (lb/hr)
Endloader	3.40	1.35	605	0.00460	2.79
Trackhoe	3.86	1.39	55	0.00442	0.243
Scraper removing	3.63	1.37	45[a]	0.96[b]	43.2
Scraper unloading	3.63	1.37	1890	0.04	75.6
Dozer	3.63	1.37			3.34
Total					125

Vehicle Travel - unpaved

	Silt %	Moisture %	Speed (mph)	Weight (ton)	Number of Wheels	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Endloader	5.62	0.56	3.0	23	4	3.0	0.41	1.23
Scraper	7.69	1.16	15	61	4	12.8	1.87	23.9
Grader	7.69	1.16	3.0	23	4	3.0	0.279	0.837
Total								26.0

[a] Cycles/hr.
[b] Lb\cycle.

Site 1.2 6/21/95 AM

Material Handling

	Silt %	Moisture %	Amount Handled (ton/hr)	PM10 Emission Factor (lb/ton)	PM10 Emission Rate (lb/hr)
Endloader	3.40	1.35	143	0.00460	0.658
Trackhoe	3.86	1.39	45	0.00442	0.199
Backhoe	3.86	1.39	4.6	0.00442	0.0203
Scraper removing	3.63	1.37	45[a]	0.96[b]	43.2
Scraper unloading	3.63	1.37	1890	0.04	75.6
Dozer	3.63	1.37			3.34
Drill			13[c]	0.98[d]	12.7
Total					136

Vehicle Travel - unpaved

	Silt %	Moisture %	Speed (mph)	Weight (ton)	Number of Wheels	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Endloader	5.62	0.56	3.0	23	4	3.0	0.41	1.23
Scraper	7.69	1.16	15	61	4	12.8	1.87	23.9
Grader	7.69	1.16	3.0	23	4	3.0	0.279	0.837
Total								26.0

[a] Cycles\hr.
[b] Lb\cycle.
[c] Holes/hr based on 10 hr day.
[d] Lb/hole.

Site 1.2 6/21/95 PM

Material Handling

	Silt %	Moisture %	Amount Handled (ton/hr)	PM10 Emission Factor (lb/ton)	PM10 Emission Rate (lb/hr)
Scraper removing	3.63	1.37	13.8[a]	0.96[b]	13.2
Scraper unloading	3.63	1.37	581	0.04	23.2
Dozer	3.63	1.37			3.34
Total					39.7

Vehicle Travel - unpaved

	Silt %	Moisture %	Speed (mph)	Weight (ton)	Number of Wheels	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Endloader	5.62	0.56	3.0	23	4	3.0	0.41	1.23
Scraper	7.69	1.16	15	61	4	13.8	1.87	25.8
Total								27.0

[a] Cycles/hr.
[b] Lb/cycle.

Site 2.1 7/14/95 AM

Material Handling

	Silt %	Moisture %	Amount Handled (ton/hr)	PM10 Emission Factor (lb/ton)	PM10 Emission Rate (lb/hr)
Trackhoe	9.72	3.10	252	0.000888	0.224
Scraper removing	3.76	1.23	6.7[a]	0.96[b]	6.43
Scraper unloading	3.76	1.23	102	0.04	4.08
Compactor	3.76	1.23			4.09
Truckdump		0.5	198	0.011	2.18
Total					17.0

Vehicle Travel - unpaved

	Silt %	Moisture %	Speed (mph)	Weight (ton)	Number of Wheels	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Scraper	3.76	1.23	15	24	4	5.4	0.0667	0.360
Grader	3.76	1.23	3.0	17	4	3.0	0.279	0.837
Truck	4.44	0.64	15	33	18	29	4.42	128
Total								129

[a] Cycles/hr.
[b] Lb/cycle.

Site 2.1 7/14/95 PM

Material Handling

	Silt %	Moisture %	Amount Handled (ton/hr)	PM10 Emission Factor (lb/ton)	PM10 Emission Rate (lb/hr)
Trackhoe	9.72	3.10	252	0.000888	0.224
Scraper removing	3.76	1.23	6.7[a]	0.96[b]	6.43
Scraper unloading	3.76	1.23	102	0.04	4.08
Compactor	3.76	1.23			4.09
Truckdump		0.5	198	0.011	2.18
Total					17.0

Vehicle Travel - unpaved

	Silt %	Moisture %	Speed (mph)	Weight (ton)	Number of Wheels	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Scraper	3.76	1.23	15	24	4	5.4	0.0667	0.360
Grader	3.76	1.23	3.0	17	4	3.0	0.279	0.837
Truck	4.44	0.64	15	33	18	29	4.42	128
Total								129

[a] Cycles/hr.
[b] Lb/cycle.

Site 2.1 7/17/95 AM

Material Handling

	Silt %	Moisture %	Amount Handled (ton/hr)	PM10 Emission Factor (lb/ton)	PM10 Emission Rate (lb/hr)
Trackhoe	9.72	3.10	252	0.000888	0.224
Scraper removing	3.76	1.23	6.7[a]	0.96[b]	6.43
Scraper unloading	3.76	1.23	102	0.04	4.08
Compactor	3.76	1.23			4.09
Endloader	9.72	3.10	630	0.000888	0.559
Total					15.4

Vehicle Travel - unpaved

	Silt %	Moisture %	Speed (mph)	Weight (ton)	Number of Wheels	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Scraper	3.76	1.23	15	24	4	5.4	0.0667	0.360
Grader	3.76	1.23	3.0	17	4	3.0	0.279	0.837
Endloader	9.72	3.10	3.0	22	4	2.3	0.686	1.58
Total								2.78

[a] Cycles/hr.
[b] Lb/cycle.

Site 2.1 7/17/95 PM

Material Handling

	Silt %	Moisture %	Amount Handled (ton/hr)	PM10 Emission Factor (lb/ton)	PM10 Emission Rate (lb/hr)
Trackhoe	9.72	3.10	252	0.000888	0.224
Scraper removing	3.76	1.23	6.7[a]	0.96[b]	6.43
Scraper unloading	3.76	1.23	102	0.04	4.08
Compactor	3.76	1.23			4.09
Endloader	9.72	3.10	630	0.000888	0.559
Total					15.4

Vehicle Travel - unpaved

	Silt %	Moisture %	Speed (mph)	Weight (ton)	Number of Wheels	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Scraper	3.76	1.23	15	24	4	5.4	0.0667	0.360
Grader	3.76	1.23	3.0	17	4	3.0	0.279	0.837
Endloader	9.72	3.10	3.0	22	4	2.3	0.686	1.58
Total								2.78

[a] Cycles/hr.
[b] Lb/cycle.

Site 2.2 7/17/95 AM

Material Handling - not present

Vehicle Travel - unpaved

	Silt %	Moisture %	Speed (mph)	Weight (ton)	Number of Wheels	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Light duty	14.00	0.39	15	2.0	4	.68	0.922	0.627
Total								0.627

Vehicle Travel - paved

	Silt Loading (g/m^2)	Weight (ton)	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Light duty	3.56	2.0	3.0	0.0127	0.0381
Light duty	5.33	2.0	0.67	0.0165	0.0111
Light duty	0.42	2.0	1.7	0.00316	0.00537
Total					0.0546

Site 2.2 7/17/95 PM

Material Handling - not present

Vehicle Travel - unpaved

	Silt %	Moisture %	Speed (mph)	Weight (ton)	Number of Wheels	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Light duty	14.00	0.39	15	2.0	4	0.73	0.922	0.673
Total								0.673

Vehicle Travel - paved

	Silt Loading (g/m^2)	Weight (ton)	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Light duty	3.56	2.0	4.2	0.0127	0.0533
Light duty	5.33	2.0	0.56	0.0165	0.00924
Light duty	0.42	2.0	1.4	0.00316	0.00442
Total					0.0670

Site 2.2 7/18/95 AM

Material Handling - not present

Vehicle Travel - unpaved

	Silt %	Moisture %	Speed (mph)	Weight (ton)	Number of Wheels	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Light duty	14.00	0.39	15	2.0	4	0.80	0.922	0.738
Total								0.738

Vehicle Travel - paved

	Silt Loading (g/m^2)	Weight (ton)	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Light duty	3.56	2.0	4.1	0.0127	0.0521
Light duty	5.33	2.0	0.70	0.0165	0.0116
Light duty	0.42	2.0	1.7	0.00316	0.00537
Total					0.0691

Site 3.1 6/27/95 AM

Material Handling

	Silt %	Moisture %	Amount Handled (ton/hr)	PM10 Emission Factor (lb/ton)	PM10 Emission Rate (lb/hr)
Scraper removing	1.38	6.95	103[a]	0.96[b]	98.9
Scraper unloading	1.38	6.95	5710	0.04	228
Scraper removing	1.38	6.95	20[a]	0.96[b]	19.2
Scraper unloading	1.38	6.95	868	0.04	34.7
Dozer	1.38	6.95			0.0806
Dozer	1.38	6.95			0.0806
Total					381

Vehicle Travel - unpaved

	Silt %	Moisture %	Speed (mph)	Weight (ton)	Number of Wheels	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Scraper	3.72	1.88	15	97	4	46.8	2.16	101
Scraper	2.58	4.56	15	78	4	9.1	0.749	6.82
Grader	2.58	4.56	3.0	17	4	3.0	0.279	0.837
Endloader	2.58	4.56	3.0	23	4	6.0	0.188	1.13
Other traffic	2.60		15	8.0	5.6	5.2	0.54	2.81
Total								113

[a] Cycles/hr.
[b] Lb/cycle.

Site 3.1 6/27/95 PM

Material Handling

	Silt %	Moisture %	Amount Handled (ton/hr)	PM10 Emission Factor (lb/ton)	PM10 Emission Rate (lb/hr)
Scraper removing	1.38	6.95	68.6[a]	0.96[b]	65.9
Scraper unloading	1.38	6.95	4220	0.04	169
Scraper removing	1.38	6.95	40[a]	0.96[b]	38.4
Scraper unloading	1.38	6.95	1740	0.04	69.6
Dozer	1.38	6.95			0.0806
Wheel dozer	1.38	6.95			0.0806
Total					343

Vehicle Travel - unpaved

	Silt %	Moisture %	Speed (mph)	Weight (ton)	Number of Wheels	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Scraper	3.72	1.88	15	106	4	31.2	2.69	83.9
Scraper	2.58	4.56	15	78	4	18.2	0.749	13.6
Grader	2.58	4.56	3.0	17	4	3.0	0.279	0.837
Other traffic	2.60		15	8.0	5.6	5.2	0.54	2.81
Total								101

[a] Cycles/hr.
[b] Lb/cycle.

Site 3.1 6/28/95 PM

Material Handling

	Silt %	Moisture %	Amount Handled (ton/hr)	PM10 Emission Factor (lb/ton)	PM10 Emission Rate (lb/hr)
Scraper removing	1.38	6.95	156[a]	0.96[b]	150
Scraper unloading	1.38	6.95	4830	0.04	193
Dozer	1.38	6.95			0.0806
Dozer	1.38	6.95			0.0806
Total					343

Vehicle Travel - unpaved

	Silt %	Moisture %	Speed (mph)	Weight (ton)	Number of Wheels	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Scraper	2.58	4.56	15	78	4	70.8	0.749	53.0
Endloader	2.58	4.56	3.0	23	4	6.0	0.188	1.13
Other traffic	2.60		15	8.0	5.6	5.2	0.54	2.81
Total								56.9

[a] Cycles/hr.
[b] Lb/cycle.

Site 3.1 6/29/95 AM

Material Handling

	Silt %	Moisture %	Amount Handled (ton/hr)	PM10 Emission Factor (lb/ton)	PM10 Emission Rate (lb/hr)
Scraper removing	1.38	6.95	48[a]	0.96[b]	46.1
Scraper unloading	1.38	6.95	2080	0.04	83.2
Scraper removing	1.38	6.95	48[a]	0.96[b]	46.1
Scraper unloading	1.38	6.95	2960	0.04	118
Dozer	1.38	6.95			0.0806
Dozer	1.38	6.95			0.0806
Total					294

Vehicle Travel - unpaved

	Silt %	Moisture %	Speed (mph)	Weight (ton)	Number of Wheels	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Scraper	2.58	4.56	15	78	4	21.8	0.749	16.3
Scraper	2.58	4.56	15	106	4	9.1	1.61	14.7
Endloader	2.58	4.56	3.0	23	4	6.0	0.188	1.13
Other traffic	2.60		15	8.0	5.6	5.2	0.54	2.81
Total								34.9

[a] Cycles/hr.
[b] Lb/hr.

Site 3.1 6/29/95 PM

Material Handling

	Silt %	Moisture %	Amount Handled (ton/hr)	PM10 Emission Factor (lb/ton)	PM10 Emission Rate (lb/hr)
Scraper removing	1.38	6.95	38.4[a]	0.96[b]	36.9
Scraper unloading	1.38	6.95	1670	0.04	66.8
Scraper removing	1.38	6.95	48[a]	0.96[b]	46.1
Scraper unloading	1.38	6.95	2960	0.04	118
Dozer	1.38	6.95			0.0806
Dozer	1.38	6.95			0.0806
Total					268

Vehicle Travel - unpaved

	Silt %	Moisture %	Speed (mph)	Weight (ton)	Number of Wheels	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Scraper	2.58	4.56	15	78	4	17.5	0.749	13.1
Scraper	2.58	4.56	15	106	4	9.1	1.61	14.7
Endloader	2.58	4.56	3.0	23	4	6.0	0.188	1.13
Other traffic	2.60		15	8.0	5.6	5.2	0.54	2.81
Total								31.7

[a] Cycles/hr.
[b] Lb/cycle.

Site 3.2 6/27/95 AM

Material Handling

	Silt %	Moisture %	Amount Handled (ton/hr)	PM10 Emission Factor (lb/ton)	PM10 Emission Rate (lb/hr)
Scraper removing	2.66	11.14	74.7[a]	0.96[b]	71.7
Scraper unloading	2.66	11.14	3970	0.04	159
Dozer	2.66	11.14			0.111
Dozer	2.66	11.14			0.111
Wheel dozer	2.66	11.14			0.111
Total					231

Vehicle Travel - unpaved

	Silt %	Moisture %	Speed (mph)	Weight (ton)	Number of Wheels	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Scraper	8.24	8.63	15	106	4	63.6	8.20	522
Other traffic	4.49	6.96	15	7.8	6.3	1.8	0.97	1.7
Total								524

Vehicle Travel - paved

	Silt Loading (g/m^2)	Weight (ton)	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Other traffic	3.43	7.8	1.4	0.095	0.13
Total					0.13

[a] Cycles/hr.
[b] Lb/cycle.

Site 3.2 6/28/95 AM

Material Handling

	Silt %	Moisture %	Amount Handled (ton/hr)	PM10 Emission Factor (lb/ton)	PM10 Emission Rate (lb/hr)
Scraper removing	2.66	11.14	110[a]	0.96[b]	106
Scraper unloading	2.66	11.14	6800	0.04	272
Dozer	2.66	11.14			0.111
Dozer	2.66	11.14			0.111
Wheel dozer	2.66	11.14			0.111
Total					378

Vehicle Travel - unpaved

	Silt %	Moisture %	Speed (mph)	Weight (ton)	Number of Wheels	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Scraper	8.24	8.63	15	106	4	50.2	.8.20	412
Other traffic	4.49	6.96	15	7.8	6.3	2.9	0.97	2.8
Total								415

Vehicle Travel - paved

	Silt Loading (g/m^2)	Weight (ton)	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Other traffic	3.43	7.8	1.4	0.095	0.13
Total					0.13

[a] Cycles/hr.
[b] Lb/cycle.

Site 3.2 6/29/95 AM

Material Handling

	Silt %	Moisture %	Amount Handled (ton/hr)	PM10 Emission Factor (lb/ton)	PM10 Emission Rate (lb/hr)
Scraper removing	2.66	11.14	77.9[a]	0.96[b]	74.8
Scraper unloading	2.66	11.14	4800	0.04	192
Dozer	2.66	11.14			0.111
Dozer	2.66	11.14			0.111
Wheel dozer	2.66	11.14			0.111
Total					267

Vehicle Travel - unpaved

	Silt %	Moisture %	Speed (mph)	Weight (ton)	Number of Wheels	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Scraper	8.24	8.63	15	106	4	35.4	8.20	290
Other traffic	4.49	6.96	15	7.8	6.3	2.4	0.97	2.3
Total								292

Vehicle Travel - paved

	Silt Loading (g/m^2)	Weight (ton)	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Other traffic	3.43	7.8	1.4	0.095	0.13
Total					0.13

[a] Cycles/hr.
[b] Lb/cycle.

Site 3.2 6/29/95 PM

Material Handling

	Silt %	Moisture %	Amount Handled (ton/hr)	PM10 Emission Factor (lb/ton)	PM10 Emission Rate (lb/hr)
Scraper removing	2.66	11.14	103[a]	0.96[b]	98.9
Scraper unloading	2.66	11.14	6340	0.04	254
Dozer	2.66	11.14			0.111
Dozer	2.66	11.14			0.111
Wheel dozer	2.66	11.14			0.111
Total					353

Vehicle Travel - unpaved

	Silt %	Moisture %	Speed (mph)	Weight (ton)	Number of Wheels	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Scraper	8.24	8.63	15	106	4	46.8	8.20	384
Other traffic	4.49	6.96	15	7.8	6.3	2.4	0.97	2.3
Total								386

Vehicle Travel - paved

	Silt Loading (g/m^2)	Weight (ton)	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Other traffic	3.43	7.8	1.4	0.095	0.13
Total					0.13

[a] Cycles/hr.
[b] Lb/cycle.

Site 5.2 8/1/95 AM

Material Handling

	Silt %	Moisture %	Amount Handled (ton/hr)	PM10 Emission Factor (lb/ton)	PM10 Emission Rate (lb/hr)
Scraper removing	23.0	7.84	24[a]	0.96[b]	23.0
Scraper unloading	23.0	7.84	408	0.04	22.8
Trackhoe	5.13	5.05	67	0.00041	0.028
Compactor	23.0	7.84			4.6
Total					50.4

Vehicle Travel - unpaved

	Silt %	Moisture %	Speed (mph)	Weight (ton)	Number of Wheels	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Scraper	16.2	0.64	15	38.5	4	18.2	1.68	30.6
Grader	19.4	0.56	3.0	20	6	3.0	0.279	0.837
Other traffic	19.4	0.56	5.0	5.5	4.8	0.45	0.96	0.43
Total								31.9

[a] Cycles/hr.
[b] Lb/cycle.

Site 5.2 8/1/95 PM

Material Handling

	Silt %	Moisture %	Amount Handled (ton/hr)	PM10 Emission Factor (lb/ton)	PM10 Emission Rate (lb/hr)
Scraper removing	23.0	7.84	48[a]	0.96[b]	46.1
Scraper unloading	23.0	7.84	816	0.04	45.6
Trackhoe	5.13	5.05	76	0.00041	0.031
Compactor	23.0	7.84			4.6
Total					96.3

Vehicle Travel - unpaved

	Silt %	Moisture %	Speed (mph)	Weight (ton)	Number of Wheels	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Scraper	16.2	0.64	15	38.5	4	10.0	1.68	16.8
Endloader	22.6	0.47	3.0	21	4	3.0	1.56	4.7
Grader	19.4	0.56	3.0	20	6	3.0	0.279	0.837
Other traffic	19.4	0.56	5.0	5.5	4.8	0.45	0.96	0.43
Total								22.8

[a] Cycles/hr.
[b] Lb/cycle.

Site 5.2 8/2/95 AM

Material Handling

	Silt %	Moisture %	Amount Handled (ton/hr)	PM10 Emission Factor (lb/ton)	PM10 Emission Rate (lb/hr)
Scraper removing	23.0	7.84	15[a]	0.96[b]	14.4
Scraper unloading	23.0	7.84	483	0.04	19.3
Trackhoe	5.13	5.05	176	0.00041	0.072
Truckdump	7.42	4.21	370	0.00053	0.20
Compactor	23.0	7.84			4.6
Total					38.6

Vehicle Travel - unpaved

	Silt %	Moisture %	Speed (mph)	Weight (ton)	Number of Wheels	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Scraper	16.2	0.64	15	53	4	7.1	3.73	26.5
Endloader	22.6	0.47	3.0	21	4	3.0	1.56	4.7
Grader	19.4	0.56	3.0	20	6	3.0	0.279	0.837
Truck	23.5	4.34	15	30	18	7.1	22.1	157
Other traffic	19.4	0.56	5.0	5.5	4.8	0.45	0.96	0.43
Total								189

[a] Cycles/hr.
[b] Lb/cycle.

Site 5.2 8/2/95 PM

Material Handling

	Silt %	Moisture .%	Amount Handled (ton/hr)	PM10 Emission Factor (lb/ton)	PM10 Emission Rate (lb/hr)
Trackhoe	5.13	5.05	286	0.00041	0.12
Truckdump	7.42	4.21	504	0.00053	0.27
Compactor	23.0	7.84			4.6
Total					4.99

Vehicle Travel - unpaved

	Silt %	Moisture %	Speed (mph)	Weight (ton)	Number of Wheels	Vehicle Miles Travelled per Hour (VMT/hr)	Uncontrolled PM10 Emission Factor (lb/VMT)	Uncontrolled PM10 Emission Rate (lb/hr)
Endloader	22.6	0.47	3.0	21	4	3.0	1.56	4.7
Grader	19.4	0.56	3.0	20	6	3.0	0.279	0.837
Truck	23.5	4.34	15	30	18	9.7	22.1	214
Other traffic	19.4	0.56	5.0	5.5	4.8	0.45	0.96	0.43
Total								220

Appendix C

Assumptions Used to Develop Level 2 Estimates

This appendix details how the default values used in Level 2 of Table 7 were developed.

C-1 On-site Haulage

Assumption	Basis
Cat 631 scraper	Considered typical capacity, most common size seen in site visits
3,000 ft round trip distance with • 250 ft in cut • 250 ft in fill • 1,000 ft in between	Based on site visits
Load time 0.6 min Manuever/dump time of 0.7 min	Table on p. 8-11 of Cat Performance Handbook (Reference 2 in the body of the report)
Total resistance of 8% on 1,000 ft travel route loaded time = 1.2 min empty time = 0.8 min	8% based on middle value in graphs given below loaded table on p 8-37 of handbook empty table on p 8-38
Total cycle time = 3.3 min	
Hourly production based on 50 min/hr, 75,000 lb payload, and 1.4 ton/cu yd to give **400 cu yd/hr = 70,000 cy/month**	50 min/hr under **Job Efficiency** on p 19-8 75,000 lb from p 8-37

C.2 Over-the-road Trucks

Only two sites were observed with periods of extensive over-the-road truck haulage. On the first observation day at Site 2.1, trucks were used to stockpile material with 198 tons per hour being delivered. During the second observation day at Site 5.2, trucks were used to bring in fill material at a rate of 370 tons per hour. Based on a density of 1.4 ton per cubic yard (cy), the average rate is estimated as 150 cy/hr or approximately 35,000 cy/month.