Emission Tests of Paved Road Traffic at Minnesota Corn Processors Columbus, Nebraska, Facility

Test Report

For
McVehil-Monnett Associates

MRI Project No. 310212.1.002

July 13, 2001

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For
McVehil-Monnett Associates
44 Inverness Drive East
Building C
Englewood, Colorado 80112

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Preface

This report presents the results from a field testing program conducted to evaluate emissions from paved roads at Minnesota Corn Processors' plant in Columbus, Nebraska. The report has been prepared under a contract with McVehil-Monnett Associates (MMA). Dr. George McVehil is MMA's program manager. Dr. Gregory E. Muleski served as MRI's project leader and authored this report. The assistance of Mr. Louie Lutjelusche in coordinating traffic during test periods is gratefully acknowledged.

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Section 1. Introduction

The U. S. Environmental Protection Agency's (EPA's) *Compilation of Air Pollutant Emission Factors* (commonly referred to as "AP-42")[1] contains factors commonly used to estimate particulate matter (PM) emissions at industrial operations. EPA guidance[2] notes that AP-42 emission factors are best viewed as representative of long-term conditions for all facilities within a source category (i.e., a population average). Furthermore, the EPA guidance[2] also notes that test data supporting AP-42 factors are usually insufficient to fully indicate the effect of various source parameters on emission levels.

These points are particularly relevant to the paved road emission factor predictive equation presented in Section 13.2.1 of AP-42:

$$e = k\,(sL/2)^{0.65}\,(W/3)^{1.5} \qquad \textbf{(1-1)}$$

e = particulate emission factor in pounds emitted per vehicle mile traveled (lb/vmt)

k = base emission factor
= 0.016 lb/vmt for particulate matter no greater than 10 microns in aerodynamic diameter (PM-10)
= 0.082 lb/vmt for total suspended particulate (TSP)

sL = surface "silt loading" which consists of mass of dried sub-200 mesh material per unit area of road surface (g/m^2)

W = average weight (ton) of vehicles traveling the road

The AP-42 emission factor model has been used to estimate PM emissions at Minnesota Corn Processors' (MCP's) plant in Columbus, Nebraska. However, in this instance, the AP-42 model has been applied to situations far beyond what is represented in the supporting data base. AP-42 states that Equation 1-1 is based on tests of emissions from freely flowing traffic moving at fairly constant speed and that no tests from slow-moving "stop-and-go" traffic are included in the data base. Traffic into and out of the MCP plant involves trucks queuing up to unload corn with frequents starts and stops. Furthermore, the plant enforces a strict speed limit of 5 mph when vehicles are moving; this is well below any of the vehicle travel speeds in the AP-42 data base.

This report presents particulate emission data specifically related to the Columbus plant. During June 2001, tests of both stop-and-go and slowly moving (5 mph) traffic were conducted at the plant. The site-specific data developed from the test program describe the actual PM emissions from paved roads at the Columbus facility better than the AP-42 factor.

It is important to note that the field program described in this report applied the exposure profiling method, which is **the same fundamental emission measurement methodology** used to develop the AP-42 data base. In other words, data generated from the field program described in this report are directly comparable to the test data supporting AP-42.

The remainder of this report is structured as follows. Section 2 presents a brief description of the test site as well as general test objectives and procedures. Section 3 provides detailed information on the test methodology. Section 4 presents and discusses the test results obtained. Section 5 lists the references cited. Appendix A presents quality assurance and quality control guidelines for the testing, while Appendix B presents detailed test results. Appendix C contains supporting information supplied by MCP.

Section 2.
General Description of the Test Program

This section describes the test location site and lists the general objectives and procedures to be followed in the test program.

2.1 Description of the MCP Columbus Facility

Figure 2-1 presents a plan view of the Columbus facility. A previous emission inventory (based on the AP-42 emission factor) showed that over 70% of the estimated PM-10 roadway emissions is related to receipt of corn. For that reason, testing focused on the inbound corn haul route immediately north of the plant. This one-way (southbound) road is approximately 0.5 mile long and is restricted to corn trucks.

2.2 Test Objectives

The overall purpose of the test program was to develop site-specific, measurement-based emission factors for paved roads at the Columbus facility. Specifically, the objectives were to develop measured emission factors that represent either (a) the stop-and-go nature of traffic at the Columbus facility or (b) the slowly moving (5 mph) traffic at the plant. Testing relied on the same exposure profiling test method used to develop the AP-42 data set. Road surface material samples were collected in connection with each test so that test results could be directly compared to the emission factor predicted from the AP-42 model (Equation 1-1).

Both emission sources of interest in this study—stop-and-go queuing and low-speed travel of trucks—can be represented as "line sources." Used in this context, a "line source" is an elongated source whose length is much greater than the distance from the source to the sampling array. All tests in the AP-42 paved road data are based on a line source representation of moving traffic.

Furthermore, trucks queued at the Columbus facility represent a line source in that all emissions (whether travel- or exhaust-related) occur along the path of motion. Natural variability in wind conditions smears the emissions along the length of the queue.

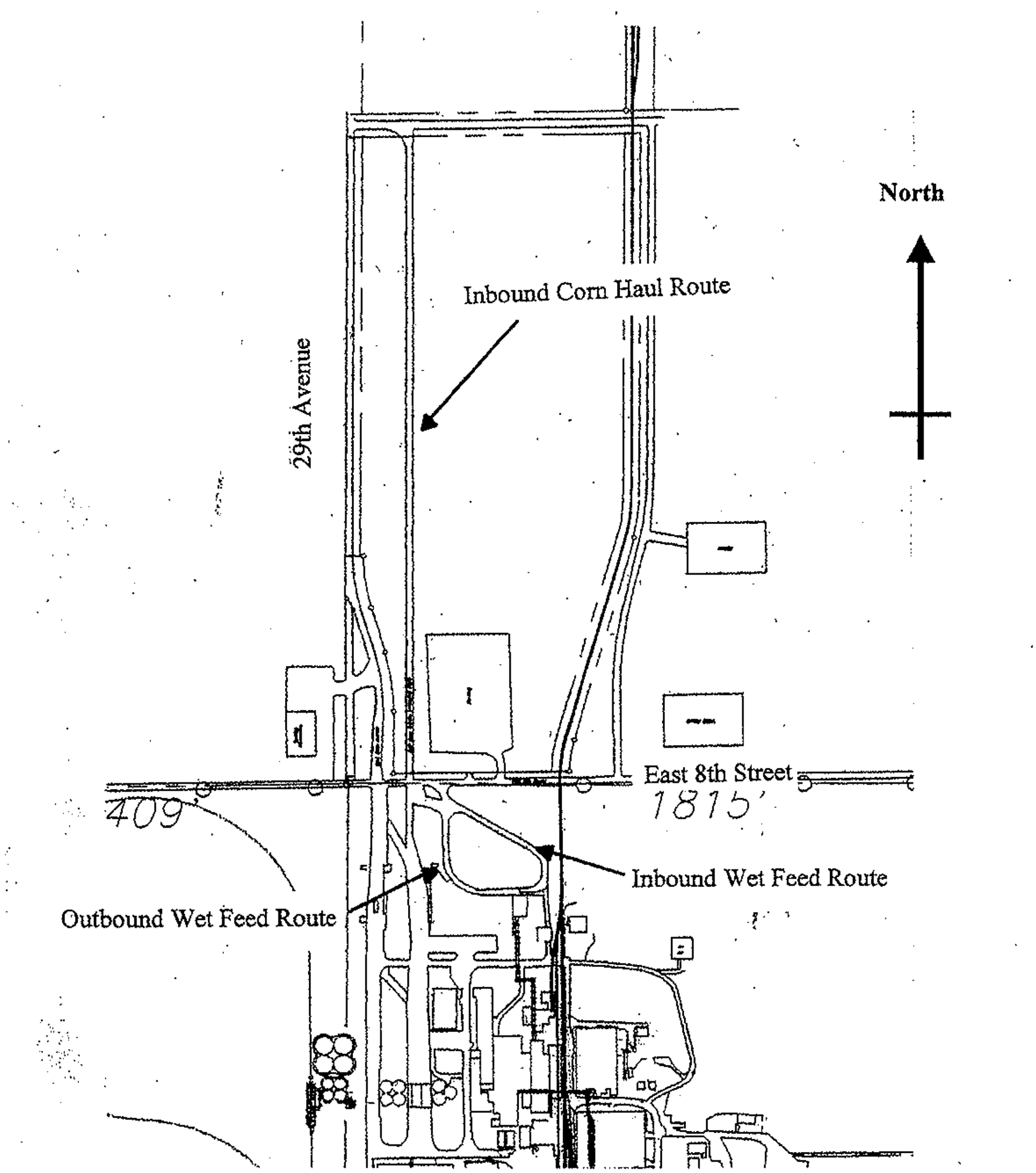

Figure 2-1. MCP Columbus Plant

Slight modifications of normal operations were made to facilitate testing. Instead of trucks queuing in three or four lines near corn receiving, plant personnel held trucks in two lines north of East 8th Street. This modification (a) extended the source to accentuate the length in relationship to the distance to the samplers; (b) allowed for simultaneously testing emissions from slowly moving and stop-and-go traffic along the inbound haul road; and (c) most importantly for exposure profiling, positioned the truck queue in an area with open wind fetch. To further promote uniformity in emissions along the line source, trucks were "staggered" along two lines rather than lining up wheel-to-wheel.

Section 3.
Test Methodology

This section discusses the exposure profiling sampling methodology employed in the program. MRI developed exposure profiling during the early 1970s and has applied the concept to a wide variety of open fugitive emission sources. AP-42 emission factors based on exposure profiling test results first appeared in 1976. Exposure profiling is EPA's preferred method to characterize emissions from fugitive dust sources. Open source emission factors based on the method typically have the highest quality ratings in AP-42.

3.1 Description of Exposure Profiling Test Method

The exposure profiling test method has been recognized by EPA as the technique most appropriate to characterize the broad class of open anthropogenic PM sources, such as material transfer and moving point sources. Because the method isolates a single emission source while not artificially shielding the source from ambient conditions (e.g., wind), the open source emission factors with the highest quality ratings in EPA's emission factor handbook AP-42[1] are typically based on this approach.

The exposure profiling technique for source testing of open particulate matter sources is based on the same isokinetic profiling concept that is used in stack testing. The passage of airborne pollutant immediately downwind of the source is measured directly by means of simultaneous multipoint sampling over the cross section of the open dust source plume. This technique uses a mass flux measurement scheme similar to EPA Method 5 stack testing rather than requiring indirect emission rate calculation through the application of a generalized atmospheric dispersion model.

The exposure profiling technique relies on simultaneous multipoint measurement of both concentration and airflow (advection) over the effective area of the emission plume. The technique uses a mass flux measurement scheme. Unlike traditional stack sources, both the emission rate and the airflow (i.e., ambient wind) are nonsteady. This requires simultaneous multipoint sampling of mass concentration and airflow over the effective area of the emission plume. As noted above, the two emission sources of interest in this study—stop-and-go queuing and low-speed travel of trucks—can be represented as "line sources." When applied to line sources, the exposure profiling test method requires a vertically oriented array of sampling points.

The sampling deployment described below is fundamentally identical to that used to develop the test data base for the AP-42 emission factor equation. As such, the emission test data for slowly moving traffic were reduced and analyzed in exactly the same manner as tests in the AP-42 data base. That is to say, the measured emission factor has been expressed in terms of mass emitted per unit of vehicle travel (e.g., lb/vmt). On the other hand, tests of trucks moving in a stop-and-go fashion were not associated with the passage of individual vehicles past the sampling array. Instead, emissions can be viewed as smeared along the length of the source, and the source strength was expressed in terms of the average emission rate (mass/length-time) during the test period.

Two vertical networks of samplers (Figure 3-1) were positioned just downwind and upwind from the edge of the source. The primary air sampling device in the exposure profiling portion of the field program was a standard high-volume air sampler fitted with a cyclone preseparator (Figure 3-2). The cyclone exhibits an effective 50 percent cutoff diameter (D_{50}) of approximately 10 μmA when operated at a flow rate of 40 cfm (68 m^3/h).[3] Thus, mass collected on the 8- by 10-inch backup filter represents a PM-10 sample.

Besides the air sampling equipment, Figure 3-1 also shows that, throughout each test, wind speed was monitored at two heights using R. M. Young Gill-type (model 27106) anemometers. Furthermore, an R. M. Young portable wind station (model 05305) was used to record wind speed and direction at the 3.0 m height. All wind data were accumulated into 5-min averages logged with a 26700 series R. M. Young "programmable translator."

Sampling activities were subject to the quality assurance/quality control (QA/QC) guidelines discussed in detail in Appendix A. Note that these are the same QA/QC guidelines used to conduct the tests contained in the AP-42 paved road data base.

3.2 Data Analysis

To calculate measurement-based emission rates and emission factors in the exposure profiling technique, a conservation of mass approach is used. The passage of airborne particulate (i.e., the quantity of emissions per unit of source activity) is obtained by spatial integration of distributed measurements of exposure (mass/area) over the effective cross section of the plume. Exposure is the point value of the flux (mass/area-time) of airborne particulate integrated over the time of measurement, or equivalently, the net particulate mass passing through a unit area normal to the mean wind direction during the test.

The concentration of particulate matter measured by a sampler is given by:

$$C = m/QT \qquad \textbf{(3-1)}$$

where: C = particulate concentration (mass/volume)
M = net mass collected on the filter or substrate (mass)
Q = volumetric flow rate of the sampler (volume/time)
T = duration of sampling (time)

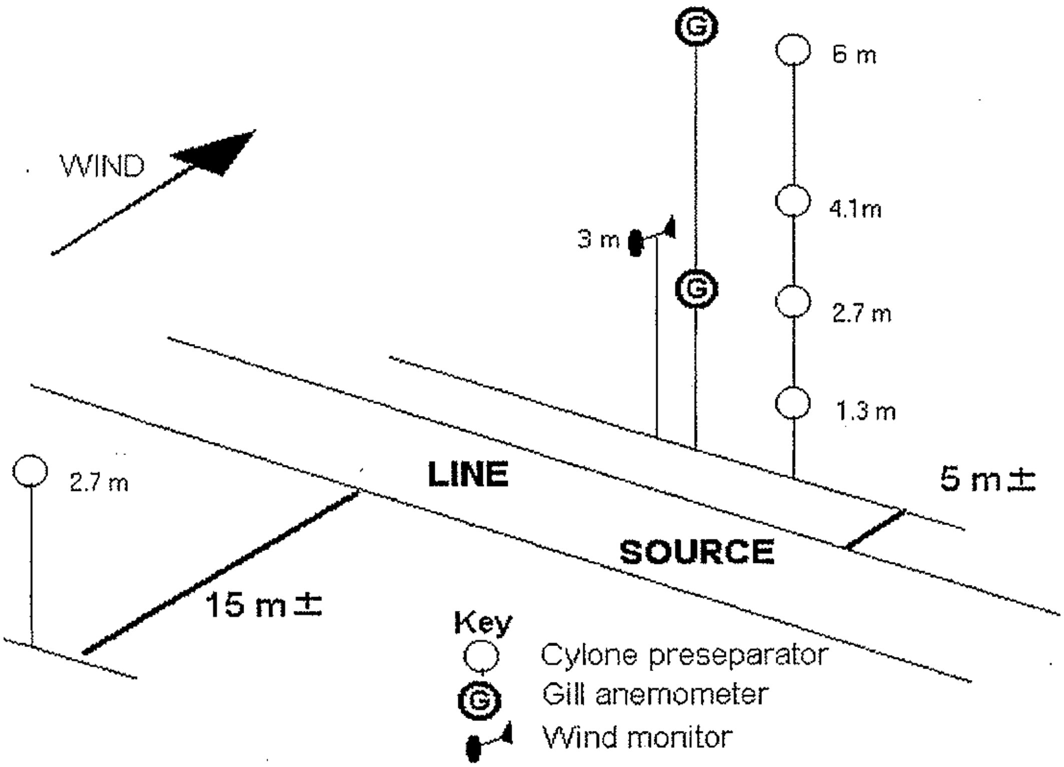

Figure 3-1. Sampler Deployment for Line Sources

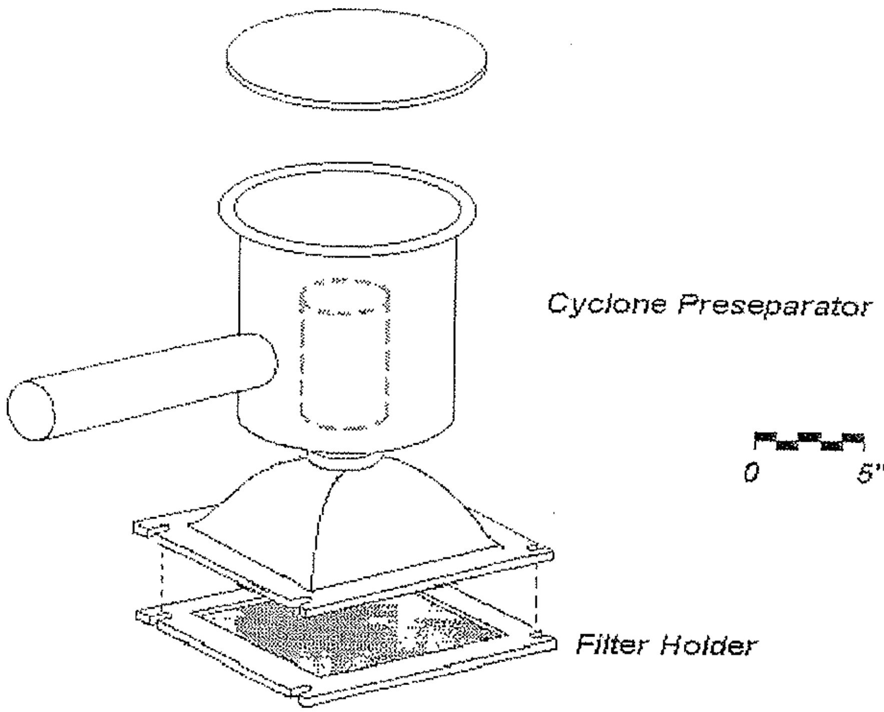

Figure 3-2. Cyclone Preseparator

The isokinetic flow ratio (IFR) is the ratio of a directional sampler's intake air speed to the mean wind speed approaching the sampler. It is given by:

$$IFR = Q/aU \tag{3-2}$$

where Q = volumetric flow rate of the sampler (volume/time)
a = sampler intake area (area)
U = approach wind speed (length/time)

This ratio is of interest in the sampling of total particulate, since isokinetic sampling ensures that particles of all sizes are sampled without bias. Because the primary interest is directed to PM-10, sampling under moderately nonisokinetic conditions poses little difficulty. It is readily recognized that 10 µm (aerodynamic diameter) and smaller particles have weak inertial characteristics at normal wind speeds and therefore are relatively unaffected by anisokinesis [4].

Exposure represents the net passage of mass through a unit area normal to the direction of plume transport (wind direction) and is calculated by:

$$E = (C - C_b)\ U\ T \tag{3-3}$$

where E = net particulate exposure (mass/area)
C = downwind particulate concentration (mass/volume)
C_b = background particulate concentration (mass/volume)
U = approach wind speed (length/time)
T = duration of sampling (time)

Exposure values vary over the spatial extent of the plume. If exposure is integrated over the plume effective cross section, then the quantity obtained represents the total passage of airborne particulate matter due to the source. For a line source, a one-dimensional integration is used:

$$A_1 = \int_0^H E\ dh \tag{3-4}$$

where A_1 = integrated exposure for a line source (mass/length)
E = net particulate exposure (mass/area)
h = height above ground (length)
H = vertical extent of the plume (length)

Because exposures are measured at discrete points within the plume, a numerical integration is necessary to determine the integrated exposure. For line sources, exposure must equal zero at the vertical extremes of the profile (i.e., at the ground where the wind velocity equals zero and at the effective height of the plume where the net concentration equals zero). However, the maximum exposure usually occurs below a height of 1 m, so that there is a sharp decay in exposure near the ground. To account for this sharp decay, the value of exposure at the ground level is set equal to the value at the lowest sampling height. The integration is performed using the trapezoidal rule.

The measured emission factor for particulate matter is determined from the integrated exposure by normalizing the emissions against some measure of source activity. For the tests of slowly moving traffic, the normalization process is the same as earlier tests supporting the AP-42 paved road emission factor model. In this case, the integrated exposure is divided by the number of vehicle passes during the emission test to express emissions in terms of mass emitted per vehicle distance traveled:

$$e = A_l / N \tag{3-5}$$

where e = measured emission factor (mass/vehicle-length)
A_l = integrated exposure for a line source (mass/length)
N = number of vehicle passes during the test

Emission measurements for the queued traffic can follow a different type of normalization. In this instance, emissions will be characterized in terms of PM mass emitted per time per unit length of the line source. In addition, the rate can be normalized to a single queue lane:

$$r = A_l / (T\ L) \tag{3-6}$$

where r = line source emission rate (mass/time-length)
A_l = integrated exposure for a line source (mass/length)
T = duration of sampling (time)
L = number of lanes used to queue traffic

Section 4.
Test Results and Discussion

This section presents and discusses the results from the field test program carried out at the MCP Columbus plant during June 2001.

4.1 Paved Road Emission Test Results

Eight PM-10 emission tests were conducted between June 12 through 15, 2001. The total comprises four tests each of stop-and-go and low-speed traffic. Because of the low level of emissions encountered during the tests, the last two tests (CF-4 and CF-5) were performed using identical upwind and downwind sampling arrays. This arrangement permitted better definition of the net contribution of roadway emissions throughout the downwind plume height.

Table 4-1 lists the test site parameters associated with each run, and Table 4-2 presents traffic data. Test locations are shown in Figure 4-1. Note that the plant provided "drone" passes by loaded corn semi-trailers to supplement traffic during test periods.

Tests generally lasted 1.5 to 5 hr in order to collect adequate sample mass on both the upwind and downwind samplers. A minimally detectable PM-10 concentration of approximately 5.7 $\mu g/m^3$ (with a confidence level of 95%) was derived, based on the following:

- The average filter blank value (0.32 mg) plus two times the standard deviation (0.13 mg) of the blanks. This produces a value of 0.32 + 2 (0.13) = 0.58 mg.
- A nominal 40 cfm sampling rate
- A nominal minimum sampling duration of 1.5 hours

Table 4-3 lists measured concentrations and exposure values for the different sampling locations. All measured concentrations were at least as large as the minimally detectable concentration value, with the majority being several times greater. The blank-corrected net catch for each exposed filter (as listed in Appendix B) was at least 10 times greater than the standard deviation of the blank values.

As discussed in preceding sections, the point values of exposure in Table 4-3 were integrated over the height of the plume to develop the emission rates and factors. Those results are shown in Table 4-4, together with the road surface silt loading data collected during the field exercise. Also shown are the AP-42 predicted emission factors calculated from Equation 1-1.

Table 4-1. Test Site Parameters[a]

Run No.	Source	Date	Start time	Duration (min)	Mean wind speed[b] (mph)	Nominal wind direction[b]	Ambient temp. (°F)	Barometric pressure (in. Hg)
CF-1/North	Low Speed	6/12/01	9:14	177	10.3	E	76	28.5
CF-1/South	Stop-and-go	6/12/01	9:10	180	10.3	E	81	28.5
CF-2/North	Low Speed	6/12/01	13:13	95	12.8	E	92	28.6
CF-2/South	Stop-and-go	6/12/01	13:18	86	12.8	E	92	28.6
CF-3/North	Low Speed	6/14/01	8:39	301	7.56	W	63	28.5
CF-3/South	Stop-and-go	6/14/01	8:43	310	7.79	W	68	28.5
CF-4/North (Downwind)	Low Speed	6/14/01	15:42	206	11.14	W	82	28.5
CF-4/North (Upwind)	Upwind[c]	6/14/01	15:42	206	"	W	82	28.5
CF-5/North (Downwind)	Stop-and-go	6/15/01	8:15	267	6.74	W	76	28.8
CF-5/North (Upwind)	Upwind[c]	6/15/01	8:15	267	"	W	76	28.8

[a] Refer to Figure 4-1 for test site locations.
[b] Wind conditions during test. Mean wind speed refers to speed measured at 5.4 m (17' 9") height during test. Nominal direction refers to cardinal direction most nearly perpendicular to line source.
[c] Upwind background test conducted to better define net contribution from road.

Table 4-2. Traffic During Tests

Run No.	Source	Avg. number of trucks[a] per hr	Avg. number of trucks in two lines	Avg. vehicle speed (mph)	Corn receipts[b] (bu) during test	Number of truck passes[a] during test
CF-1/North	Low Speed	47	–	5.0	79,730	139
CF-1/South	Stop-and-go	47	5.2	–	"	"
CF-2/North	Low Speed	66	–	5.3	76,667	104
CF-2/South	Stop-and-go	66	3.8	–	"	"
CF-3/North	Low Speed	54	–	5.1	122,874	272
CF-3/South	Stop-and-go	54	–	–	"	"
CF-4/Downwind	Low Speed	86	–	4.7	30,828	295
CF-5/Downwind	Stop-and-go	52	3.6	–	53,241	233

[a] Includes only corn trucks and other semis.
[b] Actual (i.e., not increased by "drone" passes used to increase truck queue) corn receipts during period approximately concurrent with test period.

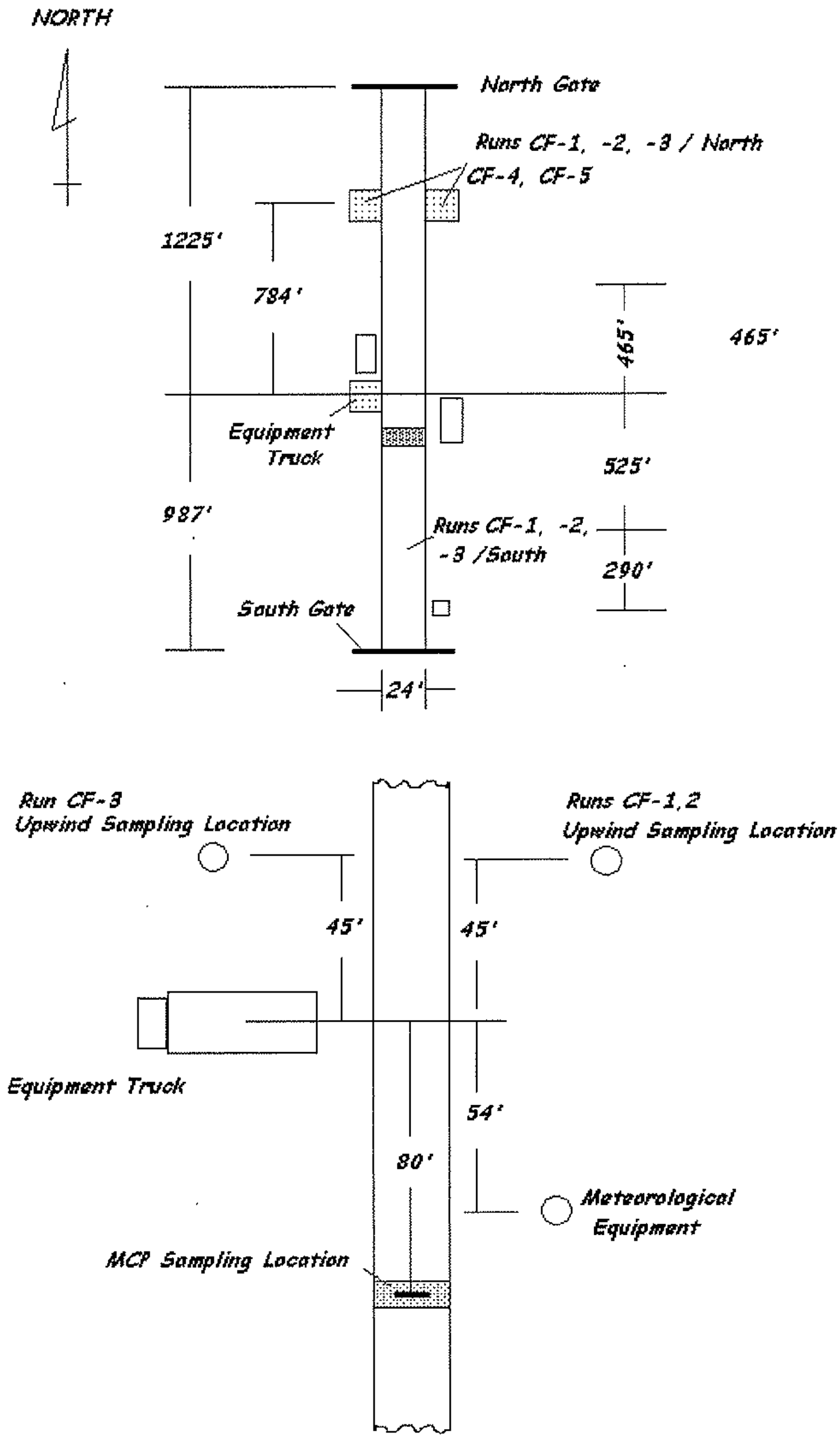

Figure 4-1. Test Site Locations

Table 4-3. Plume Sampling Data

Run	Cyclone sampler height (m) / location[a]	Downwind PM-10 concentration ($\mu g/m^3$)	Net PM-10 concentration ($\mu g/m^3$)	Wind speed (mph)	PM-10 exposure (mg/cm^2)
CF-1/North	1.3 DW	31.1	0.6	6.79	0.00196
	2.7 DW	36.8	6.4	8.64	0.0261
	4.1 DW	30.7	0.2	9.70	0.00085
	6.0 DW	27.9	0[c]	10.66	0[c]
	3 UW	30.5			
CF-1/South	1.3 DW	41.9	11.4	6.83	0.0376
	2.7 DW	40.3	9.9	8.61	0.0410
	4.1 DW	35.3	4.8	9.63	0.0224
	6.0 DW	30.2	0[c]	10.56	0[c]
	3 UW	30.5			
CF-2/North	1.3 DW	34.7	4.2	4.90	0.00528
	2.7 DW	44.9	14.4	6.68	0.0245
	4.1 DW	41.8	11.3	7.71	0.0222
	6.0 DW	36.1	5.6	8.64	0.0124
	3 UW	30.5			
CF-2/South	1.3 DW	84.7	54.2	4.89	0.0611
	2.7 DW	64.4	33.9	6.67	0.0522
	4.1 DW	48.8	18.4	7.70	0.0326
	6.0 DW	44.3	13.8	8.63	0.0275
	3 UW	30.8			
CF-3/North	1.3 DW	10.6	0[b]	5.00	0[b]
	2.7 DW	14.6	1.9	6.60	0.0104
	4.1 DW	12.9	0.3	7.52	0.00175
	6.0 DW	12.5	0[b]	8.35	0[b]
	3 UW	12.6			
CF-3/South	1.3 DW	25.6	13.0	5.23	0.0565
	2.7 DW	24.4	11.7	6.86	0.0670
	4.1 DW	26.5	13.9	7.79	0.0898
	6.0 DW	15.7	3.1	8.65	0.0223
	3 UW	12.6			
CF-4/North (Upwind)	1.3 UW	14.2			
	2.7 UW	11.7			
	4.1 UW	11.6			
	6.0 UW	9.9			
CF-4/North (Downwind)	1.3 DW	18.5	4.3	6.96	0.0164
	2.7 DW	14.6	2.9	10.05	0.0161
	4.1 DW	5.9	0[b]	11.82	0[b]
	6.0 DW	7.1	0[b]	13.43	0[b]
CF-5/North (Upwind)	1.3 UW	14.8			
	2.7 UW	12.9			
	4.1 UW	15.0			
	6.0 UW	13.4			
CF-5/North (Downwind)	1.3 DW	31.7	16.9	4.78	0.0578
	2.7 DW	26.1	13.2	5.97	0.0564
	4.1 DW	19.8	4.8	6.64	0.0229
	6.0 DW	13.3	0[b]	7.26	0[b]

[a] DW = downwind, UW = upwind
[b] No net mass attributed to test source. Zero value assumed in integration.

Table 4-4. Measurement-Based PM-10 Emission Rates/Factors

Run	Traffic rate[a] (veh/hr)	Mean vehicle[a] weight (tons)	Silt loading (g/m^2)	Measured line source emission rate (g/mile-s)	Measured per vehicle[a] emission factor (lb/vmt)	AP-42 predicted emission factor (lb/vmt)
CF-1/North	47	40	0.97	0.066	0.011	0.49
CF-1/South	47	40	0.97	0.26	0.043	0.49
CF-2/North	66	41	0.81	0.30	0.036	0.44
CF-2/South	66	41	0.81	1.1	0.14	0.44
CF-3/North	54	41	0.63	0.016	0.0024	0.38
CF-3/South	54	41	0.63	0.34	0.051	0.38
CF-4/North	86	41	1.1	0.073	0.0068	0.53
CF-5/North	52	41	1.4	0.24	0.036	0.64

[a] Includes only corn trucks and other semi-trailers. Vehicle weights supplied by MCP are presented in Appendix C.

[b] Based on 2 lines of queued traffic.

4.2 Discussion of Test Results

All measured emission factors in Table 4-4 are well below the AP-42 predicted emission factor. Because there is only a 0.4% ($=1 / 2^8$) probability that all eight measurement-based emission factors would be below that value by chance alone, one can be highly confident that AP-42 substantially overpredicts emissions for the source conditions present at the Columbus plant. The average measurement-based emission factors determined during the testing are shown below in Table 4-5.

Table 4-5. Average Measured Emission Factors

	Measured PM-10 emission factor (lb/vmt)	
	Average	Standard deviation
Stop-and-go traffic (n=4)	0.014	0.015
Slowly moving traffic (n=4)	0.066	0.046
Overall (n=8)	0.040	0.042

On average, the measured PM-10 emission factors are approximately 8 times lower than the AP-42 prediction of 0.33 lb/vmt currently applied to the Columbus facility.

Section 5.
References

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Appendix A

Quality Assurance/Quality Control Procedures

A.1 Sample Handling and Traceability Requirements

The majority of environmental samples collected during the test program consist of particulate matter captured on a filter medium. Analysis is gravimetric, as described in the following paragraphs.

To maintain sample integrity, the following procedure was used. Each filter was stamped with a unique 7-digit identification number. SOP (standard operating procedure) MRI-8403 describes the numbering system that is employed. A file folder is also stamped with the identification number and the filter is placed in the corresponding folder.

Particulate samples are collected on glass fiber (or quartz) filters (8 in by 10 in) or on glass fiber impaction substrates (4 in by 5 in). Prior to the initial (tare) weighing, the filter media are equilibrated for 24 hr at constant temperature and humidity in a special weighing room. Temperature and humidity levels are given in Table A-1. The room contains a hygrothermograph to provide a permanent record of equilibration conditions. The chart is changed weekly and recalibrated (as necessary) against wet and dry bulb thermometers. Those thermometers are checked annually against traceable units.

During weighing, the balance is checked at frequent intervals with standard (Class S) weights to ensure accuracy. The filters remain in the same controlled environment until a second analyst reweighs them as a precision check. A minimum of ten percent (10%) (with an absolute minimum of three blanks per test site) of the filters used in the field serve as blanks to account for the effects of handling. The QA guidelines pertaining to preparation of sample collection media are presented in Section A-3.

The filters are placed in their like-numbered folders. Groups of approximately 50 are sealed in heavy-duty plastic bags and stored in a heavy corrugated cardboard box equipped with a tight-fitting lid. Unexposed filters are transported to the field in the same truck as the sampling equipment and are then kept in the field laboratory.

Once they have been used, exposed filters are placed in individual glassine envelopes and then into numbered file folders. Groups of up to 50 file folders are sealed within heavy-duty plastic bags and then placed into a heavy-duty cardboard box fitted with a lid. Exposed and unexposed filters are always kept separate to avoid any cross-contamination. When exposed filters and the associated blanks are returned to the main MRI laboratory in Kansas City, they are equilibrated under the same conditions as the initial weighing. After reweighing, a minimum of 10% of each type is audited to check weighing accuracy.

In order to ensure traceability, all filter and material sample transfers are recorded in a notebook or on forms. The following information are recorded: the assigned sample codes, date of transfer, location of storage site, and the names of the persons initiating and accepting the transfer.

A.2 Analytical Method Requirements

All analytical methods required for this testing program are inherently gravimetric in nature. That is to say, the final and tare weights are used to determine the net mass of particulate captured on filters and other collection media. The tare and final weights of blank filters are used to account for the systematic effects of filter handling.

The following procedures are followed whenever a sample-related weighing is performed:

- An accuracy check at the minimum of one level, equal to approximately the tare and actual weight of the sample or standard. Standard weights should be class S or better.
- The observed mass of the calibration weight (not including the tare weight) must be within 1.0% of the reference mass.
- If the balance calibration does not pass this test at the beginning of the weighing, the balance should be repaired or another balance should be used. If the balance calibration does not pass this test at the end of a weighing, the samples or standards should be reweighed using a balance that can meet these requirements.

A.3 Quality Control Requirements

Routine audits of sampling and analysis procedures are to be performed. The purpose of the audits is to demonstrate that measurements are made within acceptable control conditions for particulate source sampling and to assess the source testing data for precision and accuracy. Examples of items audited include gravimetric analysis, flow rate calibration, data processing, and emission factor calculation. The mandatory use of specially designed reporting forms for sampling and analysis data obtained in the field and laboratory aids in the auditing procedure.

To prepare hi-vol filters for use in the field, filters are weighed under stable temperature and humidity conditions. After they are weighed and have passed audit weighing, the filters are packaged for shipment to the field. Table A-1 outlines the general requirements for conditioning and weighing sampling media. Note that a second, independent analyst performs the audit weights.

Table A-1. Quality Assurance Procedures for Sampling Media

Activity	QA check/requirement
Preparation	Inspect and imprint glass fiber media with identification numbers.
Conditioning	Equilibrate media for 24 h in clean controlled room with relative humidity of 40% (variation of less than ±5% RH) and with temperature of 23°C (variation of less than ±1°C).
Weighing	Weigh hi-vol filters to nearest 0.05 mg.
Auditing of weights	Independently verify final weights of 10% of filters and substrates (at least four from each batch). Reweigh entire batch if weights of any hi-vol filters deviate by more than ±2.0 mg. For tare weights, conduct a 100% audit. Reweigh any high-volume filter whose weight deviates by more than ±1.0 mg. Follow same procedures for impactor substrates used for sizing tests. Audit limits for impactor substrates are ±1.0 and ±0.5 mg for final and tare weights, respectively.
Collection of blanks	Conduct at least one complete blank test for every 1 to 9 emission tests. A minimum of 3 blank filters is necessary for each test site/source combination.
Calibration of balance	Balance to be calibrated once per year by certified manufacturer's representative. Check prior to each use with laboratory Class S weights.

As indicated in Table A-1, a minimum of 10% field blanks are collected for QC purposes. This is accomplished by conducting one blank test for every 1-to-9 emission tests conducted. A blank test is conducted in exactly the same manner as an emission test except that no air is passed through the filters after they are loaded into the sampling devices. Instead, they are immediately recovered and handled the same as any exposed filter from an actual emission test. Blank runs are labeled in the same manner as other tests, although the run sheets indicate that a blank test was conducted.

Handling blank filters in an identical manner to all sample filters allows one to determine systematic weight changes due to handling steps alone. A field blank filter is loaded into a sampler and then immediately recovered without any air being passed through the media. This technique has been successfully used in many MRI programs to account for systematic weight changes due to handling.

After the particulate matter samples and blank filters are collected and returned from the field, the collection media are placed in the gravimetric laboratory and allowed to come to equilibrium. Each filter is weighed, allowed to return to equilibrium for an additional 24 hr, and then a minimum of 10% of the exposed/blank filters are reweighed. If a filter fails the audit criterion, the entire lot is allowed to condition in the gravimetric laboratory an additional 24 hr and then reweighed. The tare and first weight criteria for filters (Table A-1) are based on an internal MRI study conducted in the early 1980s to evaluate the stability of several hundred 8- x 10-in glass fiber filters used in exposure profiling studies.

A.4 Instrument/Equipment Testing, Inspection and Maintenance

Inspection and maintenance requirements for sampling equipment are provided in Table A-2. Material presented in italics discusses how these requirements were met during the study.

A.5 Instrument Calibration and Frequency

Calibration and frequency requirements for the balances used in the gravimetric analyses are given in Table A-1.

Requirements for high-volume (hi-vol) sampler flow rates rely on the use of secondary and primary flow standards. The Roots meter is the primary volumetric standard and the BGI orifice is the secondary standard for calibration of hi-vol sampler flow rates. The Roots meter is calibrated and traceable to a NIST standard by the manufacturer. The BGI orifice is calibrated against the primary standard on an annual basis. Before going to the field, the BGI orifice is first checked to assure that it has not been damaged. In the field, the orifice is used to calibrate the flow rate of each hi-vol sampler. (For samplers with volumetric flow controllers, no calibration is possible and the orifice is used to audit the nominal 40 acfm flow rate.) Table A-2 specifies the frequency of calibration and other QA checks regarding air samplers.

Table A-3 outlines the QC checks employed for miscellaneous instrumentation needed. Material presented in italics discusses how these requirements were met during the study.

A.6 Inspection/Acceptance Requirements for Supplies and Consumables

The primary supplies and consumables for this field exercise consist of the air filter and collection media. Prior to stamping and initial weighing (Table A-1), each filter is visually inspected and is discarded for use if any pin-holes, tears, or other damage is found.

A.7 Data Acquisition Requirements

In addition to the field samples, MRI also collected information on the physical size and operational parameters of equipment used in the field exercise. To the extent practical and appropriate, physical characteristics are obtained from the manufacturer or the manufacturer's literature. Physical dimensions are measured and recorded.

Table A-2. Quality Assurance Procedures for Sampling Equipment

Activity	QA check/requirement[a]
Maintenance • All samplers	Check motors, brushes, gaskets, timers, and flow measuring devices at each plant prior to testing. Repair/replace as necessary. *Sampling devices were cleaned and checked prior to loading truck and upon arrival at plant.*
Calibration • Volumetric flow controller (VFC)	Prior to start of testing at each regional site, ensure that flow determined by calibration orifice and the look-up table for each volumetric flow controller agrees within 7%. Alternately, develop a separate calibration curve for each VFC. For 20 acfm devices (particle size profiling), calibrate each sampler against the orifice prior to use for each regional site and every two weeks thereafter during test period. (Orifice calibrated against displaced volume test meter annually.) *VFC calibration records have been included in copy of field data sheets. Calibration curves developed for each VFC are included on diskette with field data and data reduction.*
Operation • Timing	Start and stop all downwind samplers during time span not exceeding 1 min. *All downwind samplers were started / stopped within 1 minute.*
• Isokinetic sampling (cyclones)	Adjust sampling intake orientation whenever mean wind direction dictates. *Wind direction relative to line source monitored immediately before and throughout test. Rotation of sampling arrays noted on field run sheets.* Change the cyclone intake nozzle whenever the mean wind speed approaching the sampler falls outside of the suggested bounds for that nozzle. *Wind speed throughout range of sampling heights monitored immediately before and throughout the test. Use of nozzles indicated on field run sheets.*
• Prevention of static deposition	Cover sampler inlets prior to and immediately after sampling. *Samplers were uncovered immediately before start of test and filters recovered immediately after end of test.*

[a] "Mean" denotes a 5-min average.

Table A-3. Quality Assurance for Miscellaneous Instrumentation

Instrumentation	QA check/requirement[a]
Digital manometers	Compare reading against water-in-tube manometers over range of operating pressures, using "Y" or "T" connectors and flexible tubing. Do not use units which differ by more than 7%. *Two units were used during tests. Maximum deviations for unit Y7543 and unit Y7542 were 2.8 and 4.8%, respectively.*
Digital barometer	Compare against mercury-in-tube barometer. Do not use if more than 0.5 in Hg difference in reading. *Deviation of altimeter/barometer Y-1253 was 0.19 in Hg (0.66% deviation).*
Thermometer (mercury or digital)	Compare against NIST-traceable mercury-in-glass. Do not use if more than 3.0 C difference. *Two units used during tests. Deviation for Hg-in-glass unit was 0.7°F (0.4°C) high and for electronic unit SN 8935833 was 0.7°F (0.4°C) low.*
Gill anemometers and wind station	Conduct a 4-point calibration of each unit over the range of 2 to 20 mph both before the field exercise and upon return to MRI's main laboratories. Use factory-specified devices for calibration of wind speed and direction. *Calibration records have been supplied as part of field run sheets.*
Watches/stopwatches	The field test leader will compare an elapsed time (> 1 hr) recorded by his watch against the US Naval Observatory master clock. Do not use if more than 3% difference. All crew members will synchronize watches (to the nearest minute) at the start of each test day. *Crew chief watch was checked against 27 hr elapsed time, with deviation of 0.04%. Crew member watches and wind data acquisition device were reset to crew chief watch each day.*

[a] Activities performed prior to going to the field, except as noted.

Table A-4. Criteria for Suspending or Terminating an Exposure Profiling Test

A test may be suspended or terminated if:[a]

1. Rainfall ensues during equipment setup or when sampling is in progress. (Exception made in the case of a source protected by a roof or other enclosure).
2. Mean wind speed during sampling moves outside the 4 to 20 mph acceptable range for more than 20% of the sampling time.
3. The angle between the mean wind direction and the perpendicular to the measurement plane exceeds 45° for more than 20% of the sampling time.
4. Daylight is insufficient for safe equipment operation. (Exception made in case of adequate artificial lighting.)
5. Source conditions deviates from predetermined criteria (e.g., loading equipment malfunction, water splashing, truck spills).

[a] "Mean" denotes a 5-min average.

Appendix B
Detailed Test Data

Run	Date	Sampler Location	Sampler ID	Sampler Start Time	Sampler Stop Time	Duration (min)	Avg. Temp. (deg. F)	Avg. Bar. P. (in. Hg)	Avg. Filter Press. (in H2O)	Filter Number	Tare Wt. (g)	Final Wt. (g)	Blank Corrected* (mg)	Flow rate VFC (acfm)	Measured (raw) Conc. (ug/m3)	Net Conc. (ug/m3)	Wind Speed (mph)	Net PM-10 Exposure (mg/cm2)
CF-1/North	6/12/01	Cyclone 1.3 DW	70	9:14	12:11	177	76	28.5	20.3	121064	4.5886	4.5949	6.0	38.37	31.1	0.6	6.79	0.00196
		Cyclone 2.7 DW	76	9:14	12:11	177	76	28.5	19.7	121065	4.5845	4.5921	7.3	39.41	36.8	6.4	8.64	0.02614
		Cyclone 4.1 DW	74	9:14	12:11	177	76	28.5	21.5	121063	4.3899	4.3963	6.1	39.55	30.7	0.2	9.70	0.00085
		Cyclone 6.0 DW	75	9:14	12:11	177	76	28.5	20.2	121067	4.5968	4.6027	5.6	39.90	27.9	-2.6	10.66	0.00000
		Cyclone UW**	77	9:02	12:18	314	81	28.5	17.7	121072	4.5790	4.5903	11.0	40.52	30.5			
CF-1/South	6/12/01	Cyclone 1.3 DW	68	9:10	12:10	180	81	28.5	21.7	121068	4.4046	4.4132	8.3	38.80	41.9	11.4	6.83	0.03755
		Cyclone 2.7 DW	67	9:10	12:10	180	81	28.5	21.7	121069	4.4097	4.4185	8.5	41.23	40.3	9.9	8.61	0.04104
		Cyclone 4.1 DW	71	9:10	12:10	180	81	28.5	22.0	121070	4.4135	4.4209	7.1	39.35	35.3	4.8	9.63	0.02238
		Cyclone 6.0 DW	66	9:10	12:10	180	81	28.5	20.8	121071	4.4128	4.4191	6.0	38.90	30.2	-0.3	10.56	0.00000
		Cyclone UW	77	9:02	12:18	314	81	28.5	17.7	121072	4.5790	4.5903	11.0	40.52	30.5			
CF-2/North	6/12/01	Cyclone 1.3 DW	70	13:13	14:48	95	92	28.6	20.2	121073	4.5746	4.5786	3.7	39.40	34.7	4.2	4.90	0.00528
		Cyclone 2.7 DW	76	13:13	14:48	95	92	28.6	20.0	121074	4.5675	4.5727	4.9	40.41	44.9	14.4	6.68	0.02452
		Cyclone 4.1 DW	74	13:13	14:48	95	92	28.6	20.6	121075	4.6086	4.6135	4.6	40.75	41.8	11.3	7.71	0.02216
		Cyclone 6.0 DW	75	13:13	14:48	95	92	28.6	20.0	121076	4.5886	4.5929	4.0	40.98	36.1	5.6	8.64	0.01235
		Cyclone UW	77	9:02	15:26	314	81	28.5	17.7	121072	4.5790	4.5903	11.0	40.52	30.5			
CF-2/South	6/12/01	Cyclone 1.3 DW	68	13:18	14:44	86	92	28.6	20.8	121077	4.5920	4.6005	8.2	39.64	84.7	54.2	4.89	0.06114
		Cyclone 2.7 DW	67	13:18	14:44	86	92	28.6	21.7	121078	4.5985	4.6054	6.6	41.96	64.4	33.9	6.67	0.05218
		Cyclone 4.1 DW	71	13:18	14:44	86	92	28.6	21.0	121079	4.5699	4.5750	4.8	40.17	48.8	18.4	7.70	0.03260
		Cyclone 6.0 DW	66	13:18	14:44	86	92	28.6	20.3	121080	4.5888	4.5934	4.3	39.67	44.3	13.8	8.63	0.02748
		Cyclone UW	77	9:02	15:26*	314	81	28.5	20.9	121072	4.5790	4.5903	11.0	40.09	30.8			
	*The cyclone was off from 12:18 to 13:13 (55 min) and from 14:47 to 15:02 (15 min)																	
	**The upwind sampler was run with the same filter for runs CF-1 and CF-2																	
CF-3/North	6/14/01	Cyclone 1.3 DW	70	8:39	13:40	301	63	28.5	19.6	121081	4.6058	4.6095	3.4	37.55	10.6	-2.1	5.00	0.00000
		Cyclone 2.7 DW	76	8:39	13:40	301	63	28.5	19.5	121082	4.5812	4.5863	4.8	38.49	14.6	1.9	6.60	0.01039
		Cyclone 4.1 DW	74	8:39	13:40	301	63	28.5	19.8	121083	4.5755	4.5801	4.3	38.89	12.9	0.3	7.52	0.00175
		Cyclone 6.0 DW	75	8:39	13:40	301	63	28.5	18.9	121084	4.5721	4.5766	4.2	39.11	12.5	-0.1	8.35	0.00000
		Cyclone UW	77	8:48	14:00**	305	68	28.5	20.0	121089	4.5932	4.5978	4.3	39.26	12.6			
CF-3/South	6/14/01	Cyclone 1.3 DW	68	8:43	13:53	310	68	28.5	20.2	121085	4.5675	4.5764	8.6	38.14	25.6	13.0	5.23	0.05653
		Cyclone 2.7 DW	67	8:43	13:53	310	68	28.5	20.0	121086	4.5722	4.5812	8.7	40.57	24.4	11.7	6.86	0.06703
		Cyclone 4.1 DW	71	8:43	13:53	310	68	28.5	20.5	121087	4.5850	4.5943	9.0	38.63	26.5	13.9	7.79	0.08981
		Cyclone 6.0 DW	66	8:43	13:53	310	68	28.5	19.3	121088	4.5830	4.5886	5.3	38.25	15.7	3.1	8.65	0.02232
		Cyclone UW	77	8:48	14:00*	305	68	28.5	20.0	121089	4.5932	4.5978	4.3	39.26	12.6			
	**off from 12:50 to 12:57																	
CF-4/North (Upwind)	6/14/01	Cyclone 1.3 UW	68	15:42	19:08	206	82	28.5	20.0	121090	4.5608	4.5643	3.2	38.34	14.2			
		Cyclone 2.7 UW	67	15:42	19:08	206	82	28.5	20.7	121091	4.6147	4.6175	2.5	36.37	11.7			
		Cyclone 4.1 UW	71	15:42	19:08	206	82	28.5	20.0	121092	4.5622	4.5654	2.9	42.50	11.6			
		Cyclone 6.0 UW	66	15:42	19:08	206	82	28.5	20.2	121093	4.5984	4.6009	2.2	37.78	9.9			
CF-4/North (Downwind)	6/14/01	Cyclone 1.3 DW	70	15:42	19:08	206	82	28.5	20.3	121094	4.5778	4.5823	4.2	38.78	18.5	4.3	6.96	0.01639
		Cyclone 2.7 DW	76	15:42	19:08	206	82	28.5	20.6	121095	4.6107	4.6144	3.4	39.71	14.6	2.9	10.05	0.01612
		Cyclone 4.1 DW	74	15:42	19:08	206	82	28.5	20.3	121096	4.5751	4.5768	1.4	40.18	5.9	-5.7	11.82	0.00000
		Cyclone 6.0 DW	75	15:42	19:08	206	82	28.5	19.6	121097	4.5828	4.5848	1.7	40.40	7.1	-2.8	13.43	0.00000
CF-5/North (Upwind)	6/15/01	Cyclone 1.3 UW	68	8:15	12:42	267	76	28.8	20.3	121098	4.5902	4.5948	4.3	38.21	14.8			
		Cyclone 2.7 UW	67	8:15	12:42	267	76	28.8	20.0	121099	4.5706	4.5749	4.0	40.66	12.9			
		Cyclone 4.1 UW	71	8:15	12:42	267	76	28.8	20.8	121100	4.6038	4.6085	4.4	38.67	15.0			
		Cyclone 6.0 UW	66	8:15	12:42	267	76	28.8	19.5	121101	4.5976	4.6018	3.9	38.30	13.4			
CF-5/North (Downwind)	6/15/01	Cyclone 1.3 DW	70	8:15	12:42	267	76	28.8	20.1	121102	4.6070	4.6164	9.1	37.91	31.7	16.9	4.78	0.0578
		Cyclone 2.7 DW	76	8:15	12:42	267	76	28.8	20.1	121103	4.5689	4.5769	7.7	38.87	26.1	13.2	5.97	0.0564
		Cyclone 4.1 DW	74	8:15	12:42	267	76	28.8	20.0	121104	4.5865	4.5927	5.9	39.31	19.8	4.8	6.64	0.0229
		Cyclone 6.0 DW	75	8:15	12:42	267	76	28.8	19.8	121105	4.5836	4.5879	4.0	39.45	13.3	-0.1	7.26	0.0000

Blank Filter Data (Run CF-6).

Filter Number	Tare Wt. (g)	Final Wt. (g)	Net Wt. (mg)
121106	4.4718	4.4724	0.6
121107	4.4951	4.4953	0.2
121108	4.5016	4.5020	0.4
121109	4.4974	4.4977	0.3
121110	4.4614	4.4618	0.4
121111	4.4913	4.4915	0.2
121112	4.4943	4.4945	0.2
121113	4.5253	4.5256	0.3
121114	4.5058	4.5061	0.3
		Mean	**0.32**
		Std Dev	**0.13**

Appendix C

Material Received from MCP

Haul Road Testing Tickets

		Tuesday Morning 6/12/01			
Time In	Time Out	Ticket Number	Gross Weight	Tare Weight	Bushels
9:25	9:26	11429	86,900	26,480	1,078.929
9:28	9:31	12563	88,620	29,600	1,053.929
9:29	9:31	11430	50,360	16,320	607.857
9:30	9:33	12564	85,180	27,300	1,033.571
9:32	9:34	11432	52,960	18,100	622.500
9:32	9:35	11431	31,980	13,120	336.786
9:35	9:39	11433	81,260	27,240	964.643
9:36	9:38	12565	87,040	28,400	1,047.143
9:36	9:38	11434	88,060	31,200	1,015.357
9:38	9:41	12566	89,400	26,940	1,115.357
9:39	9:41	11435	81,000	27,580	953.929
9:39	9:43	12567	79,060	26,920	931.071
9:40	9:44	11436	81,920	29,260	940.357
9:44	9:46	11437	81,960	26,300	993.929
9:46	9:48	12568	89,080	29,620	1,061.786
9:48	9:52	12569	88,800	26,920	1,105.000
9:49	9:53	12570	89,040	29,580	1,061.786
9:50	9:52	12571	79,960	25,240	977.143
9:53	9:55	11438	81,140	26,820	970.000
9:54	9:57	12572	88,300	28,160	1,073.929
9:55	10:01	11439	60,820	21,540	701.429
9:56	9:58	12573	89,640	29,340	1,076.786
9:58	9:58	12574	77,460	27,840	886.071
10:00	10:05	12575	91,840	29,400	1,115.000
10:02	10:04	12576	79,580	28,320	915.357
10:02	10:05	12577	80,200	26,520	958.571
10:05	10:07	11441	80,080	27,560	937.857
10:06	10:08	12578	79,560	25,480	956.714
10:07	10:09	11442	63,320	21,760	742.143
10:08	10:10	11443	82,920	26,540	1,006.786
10:09	10:11	12579	79,020	29,260	888.571
10:10	10:14	12580	88,920	30,400	1,045.000
10:10	10:13	11440	84,360	27,900	1,008.214
10:11	10:13	12581	89,240	28,820	1,078.929
10:12	10:15	12582	78,540	26,520	928.929
10:14	10:16	12583	80,120	27,340	942.500
10:15	10:18	12584	81,620	24,540	1,019.286
10:15	10:17	11444	82,980	27,940	982.857
10:15	10:17	11445	81,480	28,920	938.571
10:19	10:25	12586	77,760	26,920	907.857
10:22	10:24	12587	93,560	30,780	1,121.071
10:22	10:26	12585	86,140	29,680	1,008.214
10:30	10:33	12588	90,740	29,820	1,087.857
10:41	10:43	11446	80,160	27,580	938.929
10:41	10:44	12589	88,640	30,520	1,037.857
10:43	10:49	11447	38,200	12,340	461.786
10:45	10:47	11448	80,240	26,860	953.214
10:48	10:51	12590	90,600	29,040	1,099.286
10:51	10:54	12591	88,480	30,460	1,036.071
10:57	11:00	12592	81,000	26,520	972.857
10:57	11:00	12593	80,440	27,060	953.214
10:58	11:00	12594	79,540	27,500	929.286
11:02	11:04	11449	84,360	29,180	985.357
11:04	11:07	12595	85,960	30,380	992.500

11:11	11:13	11450	80,720	27,920	942.857
11:12	11:17	11451	80,520	26,360	967.143
11:15	11:18	12596	88,460	29,540	1,052.143
11:16	11:20	12597	88,040	28,220	1,068.214
11:19	11:21	11452	80,600	27,940	940.357
11:20	11:22	12598	84,680	28,420	1,004.643
11:23	11:26	11453	80,540	27,180	952.857
11:24	11:27	12599	93,400	29,560	1,140.000
11:25	11:28	11454	81,380	28,920	936.786
11:28	11:31	12600	87,880	26,820	1,090.357
11:29	11:31	11455	63,240	21,780	740.357
11:33	11:36	11456	81,080	27,880	950.000
11:37	11:39	12601	81,420	31,280	895.357
11:37	11:40	12602	77,020	28,180	872.143
11:39	11:41	11457	61,940	22,900	697.143
11:41	11:44	12603	94,560	31,560	1,125.000
11:43	11:45	11458	88,640	31,160	1,026.429
11:47	11:50	11459	79,560	26,760	942.857
11:52	11:55	11461	79,080	28,240	907.857
11:53	11:56	12604	79,040	26,860	931.786
11:54	11:58	11460	81,600	26,420	985.357
11:57	11:59	12605	88,220	28,220	1,071.429
11:59	12:02	12607	78,020	26,860	913.571
11:59	12:02	12606	78,440	25,160	951.429
12:00	12:02	12608	92,060	30,740	1,095.000
12:04	12:06	12609	89,080	29,560	1,062.857
12:06	12:08	11462	79,120	27,520	921.429
12:09	12:13	11463	80,560	26,060	973.214
12:11	12:13	12751	87,540	30,860	1,012.143

Test Trucks (Same Numbers Used as in Afternoon Test)

Driver	Runs	Ticket Number	Gross Weight	Tare Weight	Bushels
Jerry	15	12683	83,320	27,660	993.929
Dick	14	12686	79,620	28,540	912.143
Bryan	15	12732	78,560	28,060	901.786
Jim	13	12715	79,520	28,420	915.500
Kim	12	12712	82,620	26,980	993.571
	69				
Averages			**81,036**	**27,236**	**960.610**
Averages with Test Trucks			**80,882**	**27,560**	**952.373**
Number of trucks					**83**
Number of trucks with Test Trucks					**152**

Tuesday Afternoon 6/12/01

Time In	Time Out	Ticket Number	Gross Weight	Tare Weight	Bushels
13:09	13:12	11473	79,660	26,720	945.357
13:13	13:16	11474	81,040	27,100	963.214
13:19	13:21	11475	82,600	26,460	1,002.500
13:22	13:24	12630	79,940	31,720	861.071
13:25	13:27	12631	94,020	31,180	1,122.143
13:26	13:29	12632	87,640	30,260	1,024.643
13:27	13:29	11476	81,160	27,880	951.429
13:29	13:31	11477	81,120	26,820	969.643
13:30	13:33	11478	80,320	26,260	965.357
13:31	13:33	11479	82,920	27,880	982.857

13:32	13:34	12633	79,640	26,820	943.214
13:35	13:38	12634	78,460	24,360	966.071
13:36	13:39	11480	80,200	27,580	939.643
13:39	13:42	11481	78,100	27,040	911.786
13:39	13:43	12738	89,020	29,580	1,061.429
13:40	13:43	11482	80,600	27,760	943.571
13:43	13:45	11483	80,780	26,260	973.571
13:44	13:48	12637	84,940	30,220	977.143
13:45	13:48	11484	61,980	22,860	698.571
13:45	13:48	11485	81,060	27,780	951.429
13:46	13:48	11486	81,340	27,720	957.500
13:49	13:52	12636	91,700	26,760	1,159.643
13:49	13:52	11487	79,260	26,660	939.286
13:50	13:52	12638	86,220	28,320	1,033.929
13:50	13:52	11488	80,420	27,500	945.000
13:53	13:54	12639	92,080	30,600	1,097.857
13:53	13:58	11489	37,100	12,480	439.643
13:54	13:57	12640	80,080	28,220	926.071
13:55	13:58	12641	87,040	29,100	1,034.643
14:00	14:02	12643	95,780	31,540	1,147.143
14:01	14:03	11490	79,580	27,380	932.143
14:01	14:04	12642	80,120	31,460	868.929
14:04	14:07	11491	86,520	27,840	1,047.857
14:07	14:10	11492	64,700	21,660	768.571
14:09	14:11	12644	89,220	28,120	1,091.071
14:10	14:12	12645	77,860	27,660	896.429
14:14	14:17	12646	91,200	29,420	1,103.214
14:18	14:20	12647	87,060	29,400	1,029.643
14:19	14:22	12649	94,120	31,140	1,124.643
14:20	14:23	12648	81,180	27,600	956.786
14:21	14:28	11493	82,720	26,800	998.571
14:23	14:26	11494	83,140	26,140	1,017.857
14:28	14:30	12651	77,700	28,140	885.000
14:29	14:32	12650	80,160	27,340	943.214
14:30	14:33	11495	79,660	27,380	933.571
14:33	14:36	12652	82,400	25,520	1,015.714
14:40	14:42	11496	81,640	28,820	943.214
15:08	15:11	12663	92,560	31,060	1,098.214
15:09	15:11	12664	78,420	26,780	922.143
15:10	15:14	11502	80,840	28,940	926.786
15:16	15:19	12665	82,960	29,440	955.714
15:19	15:21	11504	81,220	27,160	965.357
15:21	15:23	12666	91,040	29,680	1,095.714
15:23	15:27	11503	79,640	26,440	950.000
15:24	15:27	12667	79,980	28,340	922.143
15:24	15:27	12668	88,860	26,640	1,111.071
15:27	15:30	12669	89,420	28,820	1,082.143
15:28	15:31	12670	94,900	31,480	1,132.500
15:29	15:32	11505	64,900	21,740	770.714
15:35	15:38	11506	82,940	28,920	964.643
15:38	15:41	12671	88,800	30,280	1,045.000
15:40	15:44	12672	91,060	26,700	1,149.286
15:41	15:43	11507	81,040	26,240	978.571
15:46	15:48	11508	80,400	27,940	936.786
15:47	15:49	11509	79,820	27,300	937.857
15:47	15:48	12673	86,360	29,860	1,008.929
15:49	15:52	11510	63,020	22,840	717.500
15:50	15:55	11511	59,420	21,580	675.714

15:52	15:55	12674	89,340	30,200	1,056.071
15:53	15:55	11512	79,520	26,840	940.714
15:57	16:00	12675	86,760	28,240	1,045.000
15:59	16:02	12676	86,380	27,900	1,044.286
16:02	16:05	11513	81,060	26,360	976.786
16:05	16:07	12677	93,040	31,080	1,106.429
16:07	16:09	12678	81,400	27,440	963.571
16:13	16:15	11514	80,500	27,620	944.286
16:14	16:19	12679	80,200	27,600	939.286
16:15	16:16	12680	80,200	27,080	948.571
16:16	16:20	12681	78,140	24,160	963.929

Driver	**Test Trucks Runs**	**Ticket Number**	**Gross Weight**	**Tare Weight**	**Bushels**
Jerry	15	12683	83,320	27,660	993.929
Dick	14	12686	79,620	28,540	912.143
Bryan	15	12732	78,560	28,060	901.786
Jim	13	12715	79,520	28,420	915.500
Kim	12	12712	82,620	26,980	993.571
	69				
Averages			**81,890**	**27,544**	**970.475**
Averages with Test Trucks			**81,334**	**27,733**	**957.416**
Number of trucks					**79**
Number of trucks with Test Trucks					**148**

Thursday Morning 6/14/01

Time In	**Time Out**	**Ticket Number**	**Gross Weight**	**Tare Weight**	**Bushels**
8:50	8:54	12908	89,620	29,880	1,066.786
8:53	8:55	12909	79,460	27,620	925.714
8:53	8:59	11651	84,280	28,040	1,004.286
8:54	8:57	12910	79,000	27,840	913.571
9:05	9:08	12912	89,500	29,680	1,068.214
9:06	9:08	12911	86,900	29,400	1,026.786
9:07	9:09	12913	80,660	28,300	935.000
9:09	9:12	12914	89,160	29,700	1,061.786
9:10	9:12	12916	81,080	29,020	929.643
9:10	9:15	12915	89,140	33,520	993.214
9:11	9:13	12917	78,960	26,460	937.500
9:13	9:15	11652	88,480	30,660	1,032.500
9:15	9:17	11653	80,860	26,480	971.071
9:16	9:19	12918	89,080	28,140	1,088.214
9:18	9:20	11654	92,940	30,360	1,117.500
9:19	9:21	11655	86,580	28,360	1,039.643
9:21	9:23	11656	80,960	27,680	951.429
9:21	9:25	11657	86,940	29,220	1,030.714
9:22	9:25	11658	79,220	27,020	932.143
9:23	9:26	12919	80,440	27,700	941.786
9:26	9:29	12920	80,620	26,940	958.571
9:26	9:29	11659	80,180	27,020	949.286
9:31	9:33	11660	90,100	31,620	1,044.286
9:32	9:34	11661	79,640	26,440	950.000
9:35	9:37	12921	89,660	29,420	1,075.714
9:40	9:42	12922	80,240	27,620	939.643
9:41	9:44	11662	90,100	30,280	1,068.214
9:43	9:46	12924	86,400	28,160	1,040.000

9:44	9:46	11663	79,080	28,000	912.143
9:45	9:48	11664	81,000	28,480	937.857
9:51	9:54	12926	81,480	27,980	955.357
9:51	9:57	12925	90,700	29,520	1,092.500
9:55	9:57	12927	76,040	28,260	853.214
9:55	9:59	11665	91,960	31,020	1,088.214
10:01	10:04	11666	61,940	22,700	700.714
10:03	10:05	11667	70,700	23,020	851.429
10:07	10:08	11669	79,180	27,780	917.857
10:07	10:10	11668	79,580	27,860	923.571
10:13	10:15	11671	91,300	30,800	1,080.357
10:13	10:16	11670	83,120	28,120	982.143
10:16	10:19	12923	77,840	25,260	938.929
10:16	10:19	12928	78,680	24,460	968.214
10:16	10:20	11672	83,760	28,020	995.357
10:23	10:25	12929	79,480	27,380	930.357
10:30	10:35	12930	79,700	29,940	888.571
10:33	10:34	12931	79,460	27,480	928.214
10:33	10:36	12932	89,300	26,160	1,127.500
10:39	10:41	12933	89,280	29,820	1,061.786
10:42	10:44	12934	89,560	29,680	1,069.286
10:43	10:45	12935	86,380	29,320	1,018.929
10:44	10:47	12936	91,840	30,220	1,100.357
10:49	10:54	12937	80,180	31,100	876.429
10:50	10:52	11673	83,400	27,760	993.571
10:52	10:56	12938	89,220	29,560	1,065.357
10:56	10:58	12939	80,160	27,820	934.643
10:58	11:01	12940	78,780	26,360	936.071
11:04	11:07	11675	80,600	26,380	968.214
11:04	11:07	11674	79,600	26,780	943.214
11:05	11:08	11676	82,640	27,160	990.714
11:08	11:11	12941	91,100	30,000	1,091.071
11:09	11:12	12942	85,220	28,920	1,005.357
11:11	11:15	12943	81,700	27,740	963.571
11:15	11:19	11677	81,140	26,480	976.071
11:16	11:19	11678	80,020	27,020	946.429
11:18	11:21	12944	91,400	30,480	1,087.857
11:20	11:24	12945	79,860	26,860	946.429
11:26	11:28	12946	86,040	26,520	1,062.857
11:28	11:31	11679	88,980	30,580	1,042.857
11:30	11:32	11680	79,960	28,780	913.929
11:33	11:38	11681	78,600	28,040	902.857
11:35	11:36	11682	79,180	27,760	918.214
11:39	11:41	12947	80,460	28,260	932.143
11:40	11:42	11683	71,480	22,920	867.143
11:45	11:47	11685	80,300	26,360	963.214
11:45	11:48	12948	80,320	27,500	943.214
11:46	11:50	11684	34,200	13,200	375.000
11:47	11:49	12949	88,080	30,740	1,023.929
11:50	11:52	11686	88,160	31,500	1,011.786
11:52	11:54	11687	80,980	27,960	946.786
11:54	11:57	11688	89,660	30,160	1,062.500
11:54	11:57	11689	80,040	27,900	931.071
11:59	12:06	12950	80,700	28,080	939.643
12:01	12:04	12951	79,760	28,320	918.571
12:04	12:07	12952	81,480	26,860	975.357
12:05	12:08	12953	80,120	26,280	961.429
12:08	12:10	12954	88,860	28,080	1,085.357

12:16	12:18	11691	81,000	26,980	964.643
12:16	12:19	11690	79,240	27,160	930.000
12:20	12:23	12955	82,940	27,540	989.286
12:20	12:22	12956	80,080	25,220	979.643
12:22	12:25	12957	88,380	29,600	1,049.643
12:24	12:26	12958	80,140	27,340	942.857
12:26	12:29	12959	78,760	27,880	908.571
12:29	12:32	12960	98,600	31,620	1,196.071
12:32	12:35	11692	61,240	22,680	688.571
12:34	12:36	12961	80,960	26,480	972.857
12:35	12:37	12962	85,700	29,260	1,007.857
12:37	12:38	12963	90,200	28,360	1,104.286
12:44	12:46	11693	80,460	26,320	966.786
12:45	12:48	11694	79,860	27,940	927.143
12:46	12:46	11695	93,580	31,060	1,116.429
12:49	12:51	12964	91,840	26,000	1,175.714
12:50	12:53	12966	79,300	28,000	916.071
12:50	12:56	12965	88,740	29,460	1,058.571
12:53	12:56	12967	84,320	28,860	990.357
12:54	12:57	12968	92,220	29,900	1,112.857
12:57	13:01	12969	80,120	26,340	960.357
13:02	13:05	11696	70,280	22,860	846.786
13:04	13:08	12970	88,820	30,380	1,043.571
13:05	13:06	11697	84,420	27,660	1,013.571
13:19	13:21	12971	80,560	26,240	970.000
13:20	13:25	11698	38,360	12,200	467.143
13:22	13:25	12972	80,100	24,320	996.071
13:23	13:25	11699	97,860	31,460	1,185.714
13:26	13:29	11700	80,760	27,020	959.643
13:26	13:29	12974	91,360	29,900	1,097.500
13:26	13:29	12973	88,960	30,580	1,042.500
13:30	13:32	11701	81,960	28,000	963.571
13:31	13:33	11702	60,580	20,140	722.143
13:34	13:39	11703	87,320	29,780	1,027.500
13:34	13:37	12975	80,820	27,560	951.071
13:35	13:37	12976	80,020	25,620	971.429
13:41	13:43	12977	80,660	31,420	879.286
13:42	13:44	12978	79,540	28,120	918.214
13:45	13:49	12979	88,540	28,680	1,068.929
13:49	13:51	12980	82,160	27,760	971.429

Driver	Test Trucks Runs	Ticket Number	Gross Weight	Tare Weight	Bushels
Peter	27	12981	78,880	26,400	937.143
Bryan	25	12983	79,820	27,800	928.929
Jim	24	12984	79,980	28,180	925.000
Jerry	17	12985	83,460	27,760	994.643
Dick	30	12986	80,900	28,280	939.643
	123				

Averages	**82,418**	**27,808**	**975.187**
Averages with Test Trucks	**81,427**	**27,744**	**958.626**
Number of trucks			**126**
Number of trucks with Test Trucks			**249**

Thursday Evening 6/14/01

Time In	Time Out	Ticket Number	Gross Weight	Tare Weight	Bushels
15:29	15:33	13022	81,440	26,300	984.643
15:47	15:50	11729	89,360	29,660	1,066.071
15:48	15:51	13034	93,080	31,660	1,096.786
15:51	15:54	13033	77,640	24,720	945.000
15:52	15:54	11731	82,920	26,640	1,005.000
15:56	15:58	13036	89,760	30,840	1,052.143
15:56	15:59	13035	80,020	25,520	973.214
15:57	16:00	13037	80,500	27,640	943.929
16:00	16:01	11732	81,560	27,560	964.286
16:04	16:06	13038	86,760	29,980	1,013.929
16:15	16:17	11733	59,820	22,860	660.000
16:15	16:18	13039	92,900	31,920	1,088.929
16:15	16:18	13040	92,400	31,260	1,091.786
16:17	16:20	13041	86,020	29,100	1,016.429
16:18	16:21	11734	80,560	26,400	967.143
16:19	16:22	13042	91,180	30,040	1,091.786
16:21	16:24	13043	80,840	24,980	997.500
16:22	16:25	13044	79,320	26,080	950.714
16:23	16:25	11735	80,620	27,780	943.571
16:25	16:27	11736	53,140	18,280	622.500
16:27	16:31	11737	81,580	28,140	954.286
16:27	16:29	13046	88,520	28,160	1,077.857
16:30	16:34	13045	80,440	27,360	947.857
16:35	16:39	11738	32,640	13,120	348.571
16:39	16:42	13048	81,420	31,400	893.214
16:39	16:41	13047	80,540	26,540	964.286
16:42	16:46	11739	37,640	12,340	451.786
16:43	16:45	11740	59,080	20,100	696.071
16:46	16:49	13049	89,900	29,260	1,082.857
16:52	16:54	13050	86,000	30,440	992.143
16:54	16:56	11741	50,980	16,520	615.357
16:55	16:59	13051	93,020	26,600	1,186.071
17:30	17:35	11742	93,720	29,740	1,142.500

Driver	Test Trucks Runs	Ticket Number	Gross Weight	Tare Weight	Bushels
Dan	24	13052	89,240	29,700	1,063.214
Peter	29	13054	82,260	26,280	999.643
Mel	17	13053	80,020	27,220	942.857
Jerry	36	13055	79,520	27,660	926.071
Dick	28	13056	80,980	28,160	943.214
JR	14	13057	89,980	29,960	1,071.786
Darrel	20	13058	79,860	28,080	924.643
Rob	17	13059	80,560	27,660	944.643
Tod	18	13060	88,140	29,620	1,045.000
Kim	25	13170	79,320	26,740	938.929
Bryan	29	13082	80,260	27,680	938.929
Jim	33	13069	79,700	28,040	922.500
	290				

Averages	**78,646**	**26,332**	**934.188**
Averages with Test Trucks	**81,631**	**27,776**	**961.683**
Number of trucks			**33**
Number of trucks with Test Trucks			**323**

Friday Morning 6/15/01

Time In	Time Out	Ticket Number	Gross Weight	Tare Weight	Bushels
8:31	8:37	13092	86,560	31,080	990.714
8:48	8:54	11761	77,960	27,980	892.500
8:56	9:00	13095	87,620	29,240	1,042.500
9:01	9:05	13096	79,980	27,880	930.357
9:06	9:11	13098	85,940	29,740	1,003.571
9:17	9:22	11766	81,320	26,620	976.786
9:24	9:29	11770	79,720	26,520	950.000
9:30	9:35	13103	80,060	26,980	947.857
9:36	9:40	13105	90,380	30,000	1,078.214
9:41	9:45	13108	81,240	28,760	937.143
9:53	9:58	11775	57,880	19,800	680.000
9:59	10:04	11774	86,400	27,660	1,048.929
10:00	10:05	13114	85,000	27,160	1,032.857
10:12	10:17	13115	86,240	29,880	1,006.429
10:18	10:21	11782	81,360	28,160	950.000
10:24	10:29	13118	92,240	30,240	1,107.143
10:30	10:36	13119	89,040	28,760	1,076.429
10:39	10:44	13124	84,580	25,700	1,051.429
10:45	10:50	11786	87,360	29,420	1,034.643
10:51	10:57	13126	83,940	26,960	1,017.500
10:59	11:03	13130	79,680	24,620	983.214
11:05	11:11	11790	83,620	26,260	1,024.286
11:12	11:16	11793	80,580	26,440	966.786
11:20	11:24	13134	89,380	29,460	1,070.000
11:33	11:41	13138	80,080	25,660	971.786
11:42	11:46	11794	88,020	31,480	1,009.643
12:02	12:05	13140	79,760	31,640	859.286
12:02	12:07	11796	81,120	28,300	943.214
12:03	12:06	11797	80,040	26,780	951.071
12:06	12:09	13142	78,360	31,000	845.714
12:06	12:09	11798	81,020	27,160	961.786
12:08	12:11	11799	81,080	27,960	948.571
12:10	12:14	13141	90,480	30,520	1,070.714
12:11	12:14	11800	92,880	31,140	1,102.500
12:12	12:18	13143	89,760	29,460	1,076.786
12:14	12:18	11801	83,340	27,940	989.286
12:16	12:20	13144	90,460	29,300	1,092.143
12:19	12:21	11802	30,580	10,940	350.714
12:19	12:22	13145	84,660	28,100	1,010.000
12:21	12:24	11803	79,180	26,540	940.000
12:22	12:25	13146	80,420	27,960	936.786
12:24	12:28	13147	80,660	27,400	951.071
12:25	12:28	11804	90,140	30,480	1,065.357
12:25	12:29	13148	87,660	27,960	1,066.071
12:29	12:35	13149	88,220	28,480	1,066.786
12:30	12:34	13151	82,400	26,460	998.929
12:30	12:34	13150	92,860	29,440	1,132.500
12:35	12:38	11806	80,300	27,460	943.571
12:35	12:39	13152	87,800	29,540	1,040.357
12:36	12:43	11805	95,640	30,720	1,159.286
12:40	12:43	13153	80,200	27,800	935.714
12:41	12:45	11808	91,040	27,500	1,134.643
12:44	12:48	13154	80,680	27,100	956.786
12:45	12:49	13155	80,700	28,560	931.071

Driver	Test Trucks Runs	Ticket Number	Gross Weight	Tare Weight	Bushels
Jerry	20	13165	81,600	27,560	965.000
Steve	20	13166	81,300	27,260	965.000
Dick	23	13168	80,160	28,080	930.000
Peter	21	13169	81,760	27,120	975.714
Kim	20	13170	79,320	26,740	938.929
Dennis	20	13171	82,720	27,640	983.571
	124				

Averages		**83,104**	**27,891**	**985.952**
Averages with Test Trucks		**81,725**	**27,559**	**967.255**
Number of Trucks				**54**
Number of trucks with Test Trucks				**178**

Total Averages	**81,768**	**27,508**	**968.910**
Total Averages with Test Trucks	**81,686**	**27,773**	**962.793**
Total Number of trucks			**375**
Total Number of trucks with Test Trucks			**1050**


Columbus MCP - Corn Haul Road Looking South


Columbus MCP - Stop-and-Go Test