

**Analysis of the Fine Fraction of  
Particulate Matter in Fugitive Dust**

**Site-Specific Test and  
Quality Assurance Plan**

**Review Draft**

**For  
Western Governors' Association  
Western Regional Air Partnership (WRAP)**

**Contract No. 30204-100  
MRI Project No. 110397**

**March 10, 2005**

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**For  
Western Governors' Association  
Western Regional Air Partnership (WRAP)  
1515 Cleveland Place, Suite 200  
Denver, Colorado 80202**

**ATTN: Richard Halvey**

**Contract No. 30204-100  
MRI Project No. 110397**

**March 10, 2005**

# Preface

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This Site-Specific Test and Quality Assurance Project Plan was prepared for the Western Governors Association by Midwest Research Institute (MRI) under Contract No. 30204-100. Under this project, MRI is analyzing the fine fraction of particulate matter in fugitive dust.

Questions concerning this plan should be addressed to Dr. Chatten Cowherd, MRI Project Manager, at (816) 753-7600, Ext. 1586.

MIDWEST RESEARCH INSTITUTE

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Approved:

Roger Starnes  
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March 10, 2005

**Distribution of QAPP: (A3)**

WGA/WRAP: Lee Alter, Duane Ono

MRI: Chatten Cowherd, Gregory Muleski, Mary Ann Grelinger

**Revision History:**

Revision 0: This QAPP was prepared according to the work plan produced for the work assignment. The QAPP is prepared to be in compliance with “EPA Requirements for Quality Assurance Project Plans” (EPA QA/R-5) and (as directed in the scope of work) is limited to the elements that correspond with the ORD Category III QAPP for research projects.

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# Section 1.

## Project Management (A)

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### 1.1 Project Organization (A4)

The key MRI personnel participating in the project are listed in this section: Chat Cowherd (project manager), Greg Muleski (test leader), and Mary Ann Grelinger (internal QA coordinator).

**Dr. Chat Cowherd** will serve as the Project Manager (PM) and lead investigator for the project. He will have overall responsibility for the technical direction of the project staff, overseeing the quality of the work performed and ensuring that adequate resources are available. He will be the principal contact for all technical, administrative, and contractual issues with the WRAP TPOC and will provide guidance and direction for the technical efforts.

**Dr. Greg Muleski** will serve as test leader (TL) for this project. He will provide oversight of the day-to-day testing activity.

**Mary Ann Grelinger** will serve as quality assurance coordinator (QAC). She will provide quality assurance oversight on all phases of the testing program.

All individuals are located at MRI's Kansas City office and any correspondence to them should be directed to

Midwest Research Institute  
425 Volker Boulevard  
Kansas City, MO 64110  
816.753.7600

A brief narrative of the project-specific roles and responsibilities is given below.

The project manager will ensure corporate management that the work is conducted in accordance with the quality assurance (QA) requirements. As PM, Dr. Cowherd:

- Evaluates staff credentials to ensure that they have the requisite training and experience necessary to complete the project.
- Ensures that the program is appropriately organized with effective lines of communication and that program responsibilities and authorities for making critical decisions are clearly understood.
- Ensures that the QAC is involved in the program from the planning stage through the issuance of the final report.
- Reviews QA Project Plans (QAPP) and project-specific Standard Operating Procedures (SOPs). Ensures that program QA requirements are addressed in the

QAPP and SOPs. Ensures that the QAPP and SOPs are reviewed and approved as required.

- Ensures that the work is adequately and appropriately inspected by the TL and that the results are reviewed.
- Reviews any audit reports from the QAC or the QA Unit and reviews and evaluates responses from the TL. Ensures that the actions taken are timely and appropriate.
- Reports project status, problems, and corrective actions as required by the contract, division QA Plan, QA Program Plan, or QAPP. Reports program status to division and corporate management.
- Reviews work products and reports to ensure that QA objectives were met. Approves technical reports.

Dr. Gregory E. Muleski, the TL, will provide oversight of the day-to-day testing activity and will be responsible for conducting the work in accordance with the QA requirements. The test leader has the authority to override project staff on QA matters. As TL, Dr. Muleski:

- Evaluates staff credentials to ensure that they have the requisite training and experience necessary to complete the project.
- Ensures that the project is appropriately organized with effective lines of communication. Ensures that project responsibilities and authorities for making critical decisions are clearly understood.
- Ensures that the QAC is involved in the project from the planning stage through the issuance of the final report, is fully informed, and is kept apprised of program schedules.
- Coordinates the development of any required QAPP and project specific SOPs. Anticipates problems and helps define prevention, detection, and remedial action systems. Ensures that program and work assignment QA requirements are addressed in the QAPP. Ensures that QAPP and SOPs are reviewed and approved as required.
- Approves and enforces the QA project plan and SOPs. Justifies and approves modifications to and deviations from the QAPP and SOPs.
- Justifies deviations from MRI division QA plans and SOPs. Obtains approval for deviations from division management.
- Routinely inspects the work and documents the results in the project records.
- Ensures that the work is adequately and appropriately inspected and that the results are reviewed. Reviews any audit/inspection reports from the QAC or the QA Unit.

- Ensures that any problems detected by inspection or audit are immediately communicated to the appropriate staff, that actions taken are timely and appropriate, and that the actions taken are documented in the project records.
- Reports problems and actions taken to the PM and the QAC.
- Reports project status, problems, and corrective actions to appropriate management as required by the contract, department QA Plan, QA Program Plan, or QAPP. Reports project status to the PM.
- Reviews work products and reports to ensure that QA objectives have been met. Ensures that critical data are adequately verified and the procedures are validated. Approves all technical reports.

The MRI program quality assurance coordinator (QAC) will be Mary Ann Grelinger, who will be independent of the technical management staff. She will consult with Mr. Tom Dux of MRI's QA Unit. She will conduct general audits to ensure that work is conducted in accordance with the QAPP, MRI, and division QA requirements, and MRI corporate QA policy. She has the authority to request immediate corrective action for noncompliance to the MRI program (the MRI QA plan, division QA plans, and program QA requirements). The QAC:

- Assists in preparing all QAPP.
- Reviews and approves the QAPP, and reviews project reports.
- Conducts or directs the conduct of systems, performance evaluation, and data audits as required and reviews reports as required by corporate policy, EPA, or the program management.
- Reports audit results along with any problems and corrective action requests to the PM and division management.
- Reports project QA status to division management, and the Manager of Quality Assurance.

Dr. Robert Martig, Director, Quality and Regulatory Systems, provides QA oversight for corporate management for all programs. As a member of the QA Unit, Mr. Tom Dux, Senior QAC, provides project-specific QA oversight.

Project staff report to the PM. Project staff are responsible for conducting work in accordance with division, program, and project QA requirements. They have the authority to request information and help for problems from the Project Manager, the test leader, division management, and the QA Unit. Project staff and supervisors:

- Follow division QA plans, the QA Program Plan, and any QAPP and SOPs.
- Obtain approval from the PM for any deviations in the QA Program Plan, QAPP, or SOP.
- Report work status to the PM.

- Immediately report problems to the PM and the QAC and help resolve the problems.

## **1.2 Introduction/Background (A5)**

The WRAP Dust Emissions Joint Forum (DEJF) is interested in gathering and improving data pertaining to the PM<sub>2.5</sub> and PM<sub>10</sub> components of fugitive dust emissions. Most of the PM<sub>2.5</sub> emission factors in the US EPA's AP-42 guidance for fugitive dust sources<sup>[1]</sup> were determined by using high-volume samplers fitted with a cyclone precollector and cascade impactor. Concerns about the cyclone/impactor system have been raised regarding potential PM<sub>2.5</sub> concentration bias resulting from particle bounce. Under the same conditions, the PM<sub>2.5</sub> concentration measured using these cyclone/cascade impactors should be nearly identical to the concentration measured using an ambient PM<sub>2.5</sub> sampler that meets US EPA ambient air monitoring requirements.

## **1.3 Project Task Description (A6)**

The first phase of the testing will establish that uniform PM<sub>10</sub> concentrations can be achieved in the dust exposure chamber. These concentrations may either be held at fixed values (as might represent a developed dust storm), or they can be varied to simulate the passage of a road dust plume. This phase will be used to determine any biases in PM<sub>2.5</sub> concentrations measured with the high-volume cyclone/impactor system. The second phase of the testing will be directed to quantifying PM<sub>2.5</sub>/PM<sub>10</sub> ratios for dust generated from a range of geologic source materials. All of the other tasks relate to planning for and reporting on the two test components.

## **1.4 Quality and Measurement Objectives (A7)**

The data quality objectives for this field experiment are to:

- Determine any biases in PM<sub>2.5</sub> concentration measurement by the high-volume cyclone/cascade impactor system
- Determine PM<sub>2.5</sub>/PM<sub>10</sub> ratios for dust generated from a range of geologic materials

The data quality goals are presented in Table 1-1.

**Table 1-1. Data Quality Objectives**

Measurement	Method	Accuracy (%)	Precision (%)
PM-10 concentration	TSI DustTRAK monitor	10 <sup>a</sup>	20 <sup>b</sup>
PM-2.5 concentration	Sierra cyclone/impactor	10 <sup>a</sup>	20 <sup>b</sup>
Wind speed	Kestral anemometer	10 <sup>c</sup>	10 <sup>e</sup>
Filter weights	Analytical balance	10 <sup>d</sup>	10 <sup>f</sup>

<sup>a</sup> Based on audit against reference sampler (R&P Partisol).

<sup>b</sup> Based on range percent of co-located samplers.

<sup>c</sup> Based on calibration with manufacturer-recommended device.

<sup>d</sup> Based on Class S calibration weights.

<sup>e</sup> Based on pre- and post-test calibrations.

<sup>f</sup> Based on independent audit weights.

## 1.5 Project Narrative

The WRAP Dust Emissions Joint Forum (DEJF) is interested in gathering and improving data pertaining to the PM<sub>2.5</sub> and PM<sub>10</sub> components of fugitive dust emissions. Most of the PM<sub>2.5</sub> emission factors in the US EPA’s AP-42 guidance for fugitive dust sources<sup>[1]</sup> were determined by using high-volume samplers fitted with a cyclone precollector and cascade impactor. Under the same conditions, the PM<sub>2.5</sub> mass measured using these cyclone/cascade impactors should be nearly identical to the mass collected using an ambient PM<sub>2.5</sub> sampler that meets US EPA ambient air monitoring requirements.

## 1.6 Special Training Requirements/Certification (A8)

This testing program will be conducted by personnel who have been trained in performing air sampling for determination of emission measurements.

## 1.7 Documentation and Records (A9)

### 1.7.1 General Discussion

**Sample Collection Records:** These will include run sheets that record the date, time, and location of sampling; sampler flow rates; operator; and key observations (comments). In addition, filter log sheets will clearly identify which filter or other collection media were used in specific samplers. Data forms are also used to record the location; method of collection; and any field splits of bulk (earth) material samples taken in connection with the emission tests.

**Calibration Records:** All sampler flow calibration records will be documented as to operator: time/date of calibration; transfer standard identifier (serial number); date and result of calibration of the transfer standard to the primary standard; key observations; QC results; and any problems/corrective actions taken.

**Corrective Action Reports:** These reports will summarize problems and situations that could affect the quality of the data and discuss actions taken to resolve the problems. If a corrective action report is directly applicable, it will be included in the data package.

**Laboratory Analysis Records:** Laboratory analyses are primarily gravimetric. Bound filter laboratory books are used to record the tare, final and audit weights of all air sample collection media. Specially designed data forms are used to record the sieve and pan weights used in the moisture and silt (minus-200 mesh) analyses for the bulk samples.

### **1.7.2 Data Reporting Package Format and Documentation Control**

In transferring raw data, MRI will follow documentation practices (SOPs MRI-0021 and MRI-0056) to assure data of known and defensible quality. These also will include:

- Information will be entered on standard data forms using permanent ink. See the test plan for example forms.
- Manual corrections will be made by drawing a line through the incorrect information, leaving the original information intact and legible. Corrections will be initialed, dated, and explained by the person making the correction.
- Corrections to any existing computer spreadsheet will involve modifying the file; saving it under a new file name; and leaving the original intact.
- All recorded data will be traceable to a sampling location, sampling time, instrument, operator, measurement method, calibration records, and final sample results.

The test report will discuss data collection, QA/QC and sample results. It will be accompanied by a series of appendices that contain the raw data and supporting information. The PM will assemble the raw data files (hard copies and, as necessary, electronic versions and will prepare the report. The data package will be attached to the report as an appendix.

### **1.7.3 Data Reporting Package Archiving and Retrieval**

MRI will archive the data as required by the contract or MRI's Policy and Procedures. The following record will be archived:

- Personnel records and credentials.
- Project procedures, reports, and plans.
- All project internal correspondence, meeting minutes, etc.
- Hard copy of all raw data and field records.

## Section 2.

### Measurement/Data Acquisition (B)

The test design (Table 2-1) presents an overview of the testing program for this project. Table 2-2 presents the proposed schedule.

**Table 2-1. Test Matrix**

Task	Source materials	Concentration levels	Replication	Total No. of tests	Sampling media used
4	3  (Arizona road dust, Owens Lake surface material, selected soil)	3  (Low, moderate, high)	3  (triplicates)	27	54 8x10 filters 162 4 x 5 substrates 54 47-mm filters plus > 10% field blanks for all media
5	5  Representative soils or road surface materials	3  (low fixed, high fixed, full range variable)	3  (triplicates)	45	90 47-mm filters plus > 10% field blanks

**Table 2-2. Proposed Schedule**

Date	Milestone/deliverable
February 3, 2005	Submit a draft work plan for review and approval
March 11, 2005	Submit a draft test protocol and QAPP for review and approval
March 18, 2005	Begin Phase I testing (subsequent to start-up phase)
July 11, 2005	Complete Phase II testing for at least five (5) soil types
August 11, 2005	Submit a draft report for review and approval describing the general test procedures and results of the project
October 11, 2005	Respond to comments and submit a final report

### 2.1 Sampling Process Design (Experimental Design) (B1)

The proposed experiments will be conducted in the Aerosol Test Facility in Building 2 at MRI's Deramus Field Station. The MRI test facility consists of an existing push-through flow system (3 ft by 3 ft cross section) with an exposure chamber at the downstream end of the flow tunnel, as shown in Figure 2-1. The flow system can be operated at low air speeds (as low as 0.5 m/s) that match the isokinetic intake velocity of

the cyclone/impactor system. An 18-in diameter air return loop (not shown in Figure 2-1) connects the outlet of the exposure chamber with the inlet to the blower.

A fluidized bed will inject dust into the section of the return loop immediately upstream of the blower inlet that feeds the flow tunnel (Figure 2-2). The injection point will be at the center of the duct just downstream of an orifice designed to mix the generated dust into the airflow. The fluidized bed will aerosolize fine dust from samples of loose, dry soil. The fluidization rate will be controlled by the upward airflow through the bed.

The dust concentration in the exposure chamber will be continuously monitored by the DustTRAK monitor. The tunnel flow rate will be monitored by the pressure drop across the orifice in the return loop, which will be correlated with the centerline velocity in the exposure chamber.



**Figure 2-1. MRI Flow Tunnel Test Chamber**



**Figure 2-2. Inlet to Test Chamber Blower for Push-Through Operation**

Table 2-3 lists the air sampling equipment that will be used in the two testing phases. The EPA reference method samplers will consist of R&P Partisols for  $PM_{2.5}$  and  $PM_{10}$  measurements. The approximately 3 ft by 3 ft cross section (Figure 2-1) of the exposure chamber will provide space for the inlets of two cyclone/impactors, two Partisol samplers, and two DustTRAKs, depending on the requirements of the test being performed. The bodies of the air samplers will be placed outside the exposure chamber.

Required filter and impactor substrate media will be prepared for air sampling. Impactor substrates will be greased following the protocol traditionally used by MRI for this purpose. A temperature- and humidity-controlled gravimetrics laboratory will be used for obtaining tare and final weights of filters and greased impactor substrates.

The MRI cyclone/impactor system, shown in Figure 2-3, traditionally used to determine  $PM_{2.5}/PM_{10}$  ratios for fugitive dust, consists of a Sierra Model 230 CP cyclone with a directional intake and a Sierra Model 230 three-stage slotted-type cascade impactor. When operated at 20 acfm, the cyclone has an aerodynamic cut point of 15 microns,<sup>[2]</sup> and the cascade impactor stages have cut points of 10.2, 4.2, and 2.1 microns, respectively.

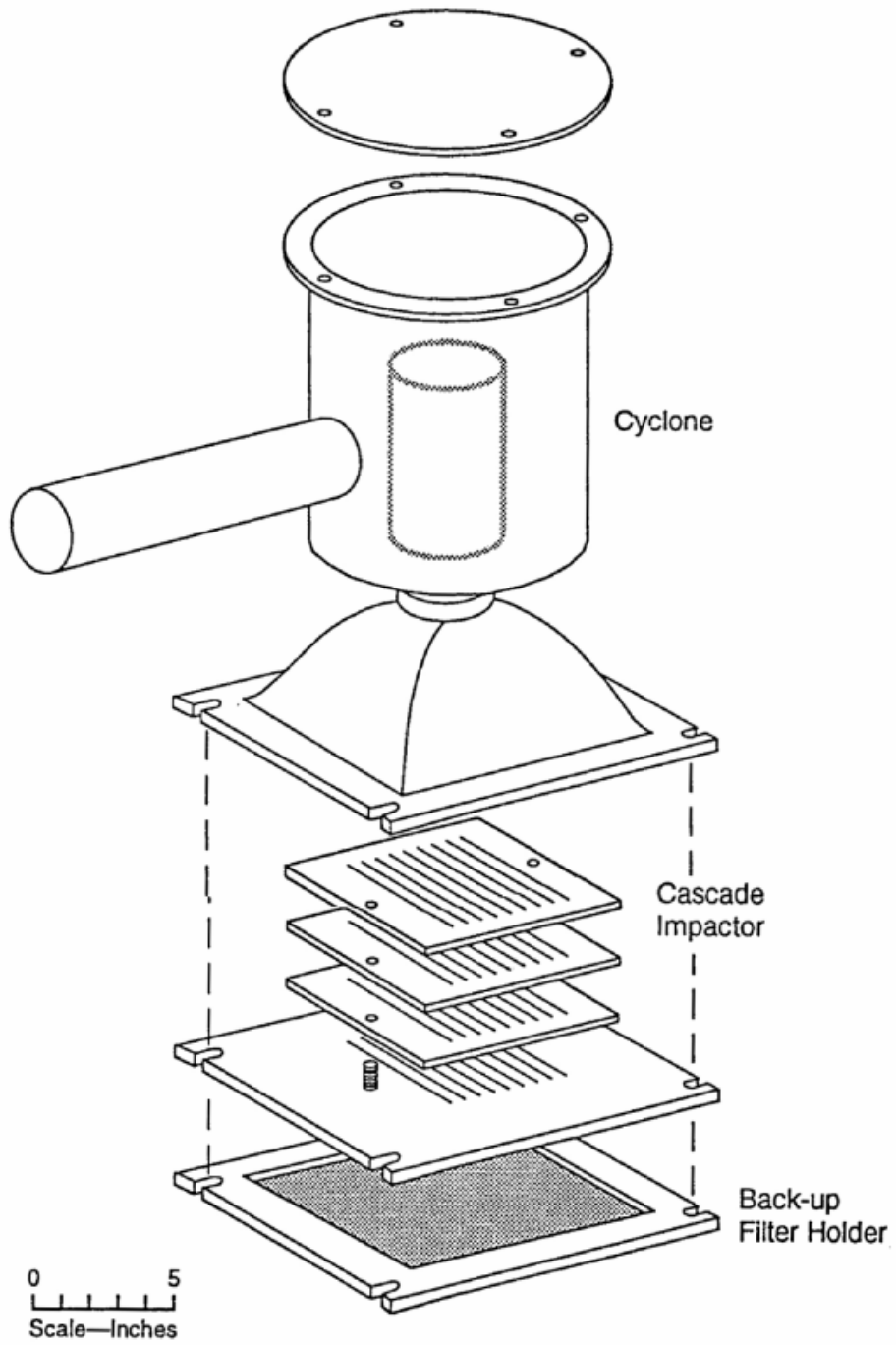
The slotted glass fiber substrates are coated with a thin film of grease before tare weighing, to mitigate against particle bounce problems. For the same reason, care is

taken not to overload the substrates with collected dust. Projection of the dust loading on the impactor stages must take into account that the PM<sub>10</sub> sample is distributed over three separate impactor stages plus the back-up filter when the cyclone is operated at 20 acfm.

Typically, the cyclone/impactor system has been utilized to generate PM<sub>2.5</sub>/PM<sub>10</sub> ratios that can be used in combination with PM<sub>10</sub> plume profiles to generate PM<sub>2.5</sub> emission factors. MRI has an inventory of cyclone/impactor systems available for the proposed program.

**Table 2-3. Air Samplers for Proposed Testing**

Task	No. in use	Sampler	Manufacturer/model	Flow rate	Comments
4	2	Cyclone preseparators	Sierra Model 230 CP	20 acfm	Third stage has D <sub>50</sub> cut of 2.1 µm, which MRI has used surrogate for PM <sub>2.5</sub> .
	4	Multistage impactor	Sierra Model 230		First three stages used.
	2	Partisol	R&P Model 2000	16.7 alpm	Device uses WINS impactor to provide PM <sub>2.5</sub> cut point.
	2	DustTRAK	TSI Model 8520	5 alpm	Used to continuously track concentration level and uniformity within exposure chamber
5	2	Partisol	R&P Model 2000	16.7 alpm	Reference sampler uses WINS impactor to provide PM <sub>2.5</sub> cut point.
	2	Partisol	R&P Model 2000	16.7 alpm	Reference sampler uses dichot inlet, which has D <sub>50</sub> cut point of 10 µm. Sampler will be fitted with R&P part to bypass WINS impactor.
	2	DustTRAK	TSI Model 8520	5 alpm	Used to continuously track concentration level and uniformity within exposure chamber.



**Figure 2-3. Sierra Model 230 Cyclone and Cascade Impactor**



**Figure 2-4. Test Chamber Interior With Flow Straightener  
(viewed from downstream exit)**

EPA reference-method R&P Partisol analyzers will be used to measure the concentrations of  $PM_{10}$  and  $PM_{2.5}$  in the dust chamber. The dust chamber will be large enough to accommodate two Partisol inlets and two cyclone/impactor inlets. MRI has available three R&P Partisol monitors for either  $PM_{10}$  or  $PM_{2.5}$ . An additional Partisol monitor will be leased for the second phase of the testing program. It should be noted that because all of the sampling systems involve collection of PM on filters (and impactor substrates), the measured concentrations represent averages over each test period expected to span 30 to 60 minutes. With regard to the filter medium, it is recommended that a fibrous rather than a membrane type filter be used for better retention of dust particles (i.e., inhibit flaking of collected particles).

Table 2-1 above shows the proposed test matrix for Tasks 4 and 5. Ten percent “field” blanks are included for all particle collection media, as is customary to meet quality control requirements.



### **2.1.1 Task 4—AP-42 PM<sub>2.5</sub> Emission Factor Evaluation**

As indicated in Table 2-1, three dust source materials will be tested under this task. It is anticipated that Owens Dry Lake surface soil will be used to provide one dust source material for the testing under Task 4. Another likely dust source material is Arizona road dust, which is available as a reference test material. The third material will likely be one provided by a WRAP member.

It is proposed that three separate PM<sub>10</sub> concentration levels (each with its naturally occurring PM<sub>2.5</sub> level) will be tested. Fixed PM<sub>10</sub> concentration levels of 500, 1,000, and 5,000 micrograms per cubic meter will be tested. The PM<sub>10</sub> concentration level during each 30- to 60-min test will be maintained as closely as possible to a predetermined target value. Tests at each concentration level will be performed in triplicate. It is expected that a total of about 27 individual tests will be performed, as shown in Table 3.

Because filter-based reference-method PM<sub>2.5</sub> monitors with relatively low sampling rates will be used in the study, the test periods may have to be extended so that minimum quantifiable mass is collected on the PM<sub>2.5</sub> (47-mm) filters. In addition, certain test soils may not have sufficient dust emission potential to achieve the higher concentrations using the dust aerosolization system.

In accordance with the test protocol and QAPP, MRI will compare the accuracy of the AP-42 cyclone/impactor PM<sub>2.5</sub> measurements to the reference method monitor for PM<sub>2.5</sub>.

### **2.1.2 Task 5—PM<sub>2.5</sub> to PM<sub>10</sub> Ratios for Different Soil Samples**

Based on the outcome of Task 4, the sampling configuration for Task 5 will be determined. It is anticipated that reference-method Partisols will measure both PM<sub>10</sub> and PM<sub>2.5</sub> concentrations. Once again, three fixed PM<sub>10</sub> concentrations (each with its naturally occurring PM<sub>2.5</sub> level) will be tested.

In accordance with the test protocol and QAPP, MRI will measure the ratio of PM<sub>2.5</sub> to PM<sub>10</sub> for fugitive dust from up to five (5) different geologic soil types. Data will include the calculation of the average PM<sub>2.5</sub> concentration and the collocated PM<sub>10</sub> concentration. Any variation in PM<sub>2.5</sub>/PM<sub>10</sub> ratio will be evaluated as a function of the test soil properties (for example, wind erodibility group).

As stated under Task 3, MRI will work with the DEJF in selecting the five soil types to be tested. These soils may come from three sources:

1. One or more of the soil samples tested under Task 4
2. Soil samples provided by WRAP members
3. Soil samples provided by USDA (with coordination by MRI)

With regard to the last source, MRI will coordinate with the USDA National Soil Survey Center in Lincoln, Nebraska. Based on previous communications with USDA, they are willing to provide soil texture analysis of all samples tested in this study as an alternative to providing actual soil samples for testing.

Table 2-4 lists critical and noncritical test measurements. In this context, “critical” indicate those measurements that are necessary to ensure that project objectives are met.

**Table 2-4. Critical and Noncritical Measurements for Emission Factors**

Measurement	Comments
Critical <ul style="list-style-type: none"> <li>• Filter weights</li> <li>• Sampler flow rates</li> <li>• Elapsed time</li> </ul>	These variables are used to calculate PM concentration.
Noncritical	
<ul style="list-style-type: none"> <li>• Barometric pressure</li> <li>• Ambient temperature</li> </ul>	These three variables are used to convert the sampling flow rate between actual and standard conditions. However, flow rate varies only slightly over the possibly encountered ranges for pressure and temperature.
<ul style="list-style-type: none"> <li>• PM concentration</li> <li>• Horizontal wind speed</li> </ul>	These variables are of interest primarily to ensure that conditions remain suitable for testing. In this way, measurements are useful for determining whether results are dependent on concentration or wind speed level.

## 2.2 Sampling Methods Requirements (B2)

The plume profiling technique for dust emission factor determination relies on simultaneous multipoint measurement of concentration and wind speed over the effective area of the emission plume. The technique uses a mass flux measurement scheme. However, both the emission rate and the air flow are non-steady. This requires simultaneous multipoint sampling of mass concentration and air flow over the effective area of the emission plume. As applied to line sources, the “exposure profiling” test method requires a vertically oriented array of sampling points.

The primary air sampling device that has been used to measure PM<sub>2.5</sub>/PM<sub>10</sub> ratios in dust plumes is a standard high-volume air sampler fitted with a cyclone preseparator and a cascade impactor. The cyclone exhibits an effective 50% cutoff diameter (D50) of approximately 10 µm when operated at a flow rate of 40 cfm (68 m<sup>3</sup>/h).<sup>[2]</sup> Thus, mass collected on the 8- by 10-in backup filter represents a PM-10 sample. When the cyclone is operated at 15 cfm (34 m<sup>3</sup>/h), it cuts at 15 µm.<sup>[2]</sup> Because the third stage of the cascade impactor cuts at 2.1 µm when operated at 15 cfm, the backup filter closely represents a PM-2.5 sample.

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

$$C = m/QT$$

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)

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:

$$\text{IFR} = Q/aU$$

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. Specially designed nozzles are available for the high-volume cyclone preseparators to maintain isokinetic (within 20%) sampling for wind speeds in the range of approximately 10 to 40 mph. Because the primary interest in this program is directed to PM-10 and PM-2.5 emissions, sampling under moderately nonisokinetic conditions should pose little difficulty. It is readily recognized that 10  $\mu\text{m}$  (aerodynamic diameter) and smaller particles have weak inertial characteristics at normal wind speeds and therefore are relatively unaffected by anisokinesis.<sup>[3]</sup>

## 2.3 Sample Handling and Custody Requirements (B3)

The majority of environmental samples collected during the test program consist of particulate matter captured on a filter medium. Analysis will be gravimetric, as described in Section 2.4.

To maintain sample integrity, the following procedure will be used. Each high-volume filter will be stamped with a unique 7-digit identification number. A file folder is also stamped with the identification number, and the filter is placed in the corresponding folder. Other filters also be associated with a unique 7-digit identification number, although the number will be placed on the filter container rather than stamped on the filter itself.

Particulate samples are collected on glass fiber filters (8 in by 10 in) and on 47-mm filters. Prior to the initial (tare) weighing, the filter media are equilibrated for 24 h at constant temperature and humidity in a special weighing room. 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 for at least 24 hr after which a second analyst reweighs them as a precision check. A minimum of ten percent (10%) of the filters and collection media used in the field will serve as blanks to account

for the effects of handling. The QA guidelines pertaining to preparation of sample collection media are presented in Section 2.5

The filters are placed in their 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 and are then kept in the field laboratory. The impactor substrates are kept in separate frames. Cases that securely hold stacks of the frames are used to transport the substrates to and from the field.

Once they have been used, exposed filters/substrates 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. All exposed and unexposed filters are always kept separate to avoid any cross-contamination. When exposed filters and the associated blanks are returned to the laboratory, they are equilibrated under the same conditions as the initial weighing. After reweighing, a minimum of 10% of each type are audited to check weighing accuracy.

## **2.4 Analytical Methods Requirements (B4)**

All analytical methods required for this testing program are inherently gravimetric in nature. That is, 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. Finally, the determination of surface moisture and silt contents are also gravimetric in nature and are described in Appendix C.2 of EPA's Compilation of Air Pollutant Emission Factors (AP-42) [2]. The following procedures are followed whenever a sample-related weighing is performed:

- An accuracy check will be performed at the minimum of one level, equal to approximately the tare weight plus the actual weight of the sample or standard. Standard weights should be class P 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 the weighing, the samples or standards should be reweighed using a balance that can meet these requirements.

## **2.5 Quality Control Requirements (B5)**

Tables 2-5, 2-6, and 2-7 list the quality assurance/quality control procedures for sampling media, sampling equipment and miscellaneous instrumentation, respectively.

**Table 2-5. Quality Control Procedures for Sampling Media**

Activity	QA check/requirement
Preparation	Inspect and imprint 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 23EC (variation of less than " 1EC).
Weighing	Weigh hi-vol filters to nearest 0.05 mg, 47-mm filters to nearest 0.001 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 that deviates by more than " 1.0 mg. Follow same procedures for impactor substrates used for sizing tests. Audit limits for 47-mm filters are " -0.010 and " 0.020 mg for final and tare weights, respectively.
Correction for handling effects	Weigh and handle at least one blank for each 1 to 10 filters of each type used to test.
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.

**Table 2-6. Quality Control Procedures for Sampling Equipment**

Activity	QA check/requirement <sup>a</sup>
Maintenance/ All samplers	Check motors, brushes, gaskets, timers, and flow measuring devices at each plant prior to testing. Repair/replace as necessary.
Calibration <ul style="list-style-type: none"> <li>Volumetric flow controller (high-volume samplers)</li> </ul>	Prior to start of testing at each regional site, ensure that flow determined by orifice and the look-up table for each volumetric flow controller agrees within 7%. For 20 acfm devices (particle size profiling), calibrate each sampler against orifice prior to use each regional site and every two weeks thereafter during test period. (Orifice calibrated against displaced volume test meter annually.)
<ul style="list-style-type: none"> <li>PM-2.5 samplers</li> </ul>	Rotameters used to set/control flow will be calibrated against bubble meter prior to going to the field. Sampling rates manually checked/reset at a minimum of every 30 minutes.
Operation <ul style="list-style-type: none"> <li>Timing/all samplers</li> </ul>	Start and stop all downwind samplers during time span not exceeding 1 min.
<ul style="list-style-type: none"> <li>Prevention of static deposition</li> <li>Isokinetic sampling (cyclones)</li> </ul>	Cover sampler inlets prior to and immediately after sampling. Change the cyclone intake nozzle whenever mean wind speed approaching the sampler falls outside of the suggested bounds for that nozzle for two consecutive averaging periods.

**Table 2-7. Quality Assurance for Miscellaneous Instrumentation**

Instrumentation	QA check/requirement <sup>a</sup>
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%.
Digital barometer	Compare against mercury-in-tube barometer. Do not use if more than 0.5 in. Hg difference in reading.
Thermometer (mercury or digital)	Compare against NIST-traceable mercury-in-glass. Do not use if more than 3.0EC difference.
Kestral anemometer	Conduct 4-point of each unit over the range of 2 to 20 mph before going to field and upon return of device to MRI's main laboratories. Use factory-specified anemometer drive device for calibration.
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.

<sup>a</sup> Activities performed prior to going to the field, except as noted.

## 2.6 Instrument/Equipment Testing, Inspection, and Maintenance Requirements (B6)

This QAPP element is not applicable to a Category III research project. (This is covered in the calibration and maintenance of sampling and analytical equipment).

## 2.7 Instrument Calibration and Frequency (B7)

Calibration and frequency requirements for the balances used in the gravimetric analyses are given in Table 2-5.

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. Table 2-6 specifies the frequency of calibration and other QC checks regarding air samplers.

Table 2-7 outlines the QC checks employed for miscellaneous instrumentation needed.

## **2.8 Inspection/Acceptance Requirements for Supplies and Consumables (B8)**

This QAPP element is not applicable to a Category III research project.

## **2.9 Data Acquisition Requirements (B9)**

In addition to field samples, MRI will also require information on the physical characteristics of the test site and number and characteristics of vehicles traveling the test road.

## **2.10 Data Management (B10)**

After returning to MRI's main laboratories, raw data will be transferred from data sheets into computer spreadsheet programs to perform the calculations (described in Section 5.2 of the site-specific test plan) leading to net concentrations. In addition to raw data, the spreadsheet also contains cells for data derived from field measurements (such as flow rates determined from “look-up” tables using air temperatures and pressures). Cell formulas are included on the spreadsheet so that the reader can readily determine how a value is calculated. Validation activities are discussed in Section 4.0.

## **Section 3.**

### **Assessment/Oversight (C)**

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The quality of the project and associated data are assessed within the project by the PM, project personnel, and peer reviewers. Oversight and assessment of the overall project quality are accomplished through the review of data, memos, audits, and reports by the program and division management and, independently, by the QAC.

#### **3.1 Assessments and Response Actions (C1)**

This section discusses project reviews, field inspections, and audits.

##### **3.1.1 Project Reviews**

The review of project data and the writing of project reports are the responsibility of the PM who also is responsible for the conduct of the first complete assessment of the project. Although the project data may have been reviewed by the project personnel and assessed as to whether the data meet the measurement quality objectives, it is the PM who must assure that overall the project activities meet the measurement and data quality objectives. The second review process is a technical peer review conducted by a technically qualified person who is familiar with the technical aspects of the project but not involved in the conduct of project activities. The peer reviewer is to present to the PM an accurate and independent appraisal of the technical aspects of the project.

The division management will assure that the project management systems are established and functioning as required by division procedures and corporate policy. The QAC will conduct the final review of the report before submittal to division management. The division management is the final review and is responsible for assuring EPA that contractual requirements have been met.

##### **3.1.2 Field Inspections**

Field inspections may be conducted by the PM or QA auditor. These inspections assess project activities that are considered important or critical to the requirements of the project. These critical activities may include, but are not limited to, sample collection and preservation, method development or validation, media preparation, or data reduction. Field inspections are assessed with respect to the QAPP, SOPs, or other established methods, and are reported to program and QA management. Any deficiencies or problems found during the inspections must be investigated with the results and

responses or corrective actions reported in a Corrective Action Report (CAR), as discussed later in this section.

### **3.1.3 Audits**

Independent systematic checks to determine the quality of the data will be performed during the conduct of this project. These checks will consist of a system and data audits as described below. In addition, the internal quality control measurements will be used to assess the performance of the analytical methodology. The combination of these, inspections, audits and the internal quality control allows the assessment of the overall data quality for this project.

The QAC is responsible for ensuring that audits are conducted as required by the QAPP. The PM is responsible for evaluating corrective action reports, taking appropriate and timely corrective actions, and informing the QAC and Project Leader of the action taken. The QAC is then responsible for ensuring that the corrective action was taken.

The system audit will be conducted by the QAC throughout the project activities. This audit will evaluate all components of the data gathering and management system to determine if these systems have been properly designed to meet the quality assurance objectives for this study. The system audit includes a careful review of the experimental design, the test plan, and the field and laboratory procedures. This review includes personnel qualifications, adequacy, and safety of the facilities and equipment, SOPs, and the data management system.

The system audit starts with the review of study protocols, procedures, and experimental design to ensure that they can meet the data quality objectives for the study. During the system audit, the QAC will inspect the analytical laboratory and determine the laboratory's adherence to the SOPs and the QAPP. The QAC reports any area of nonconformance to the project leader, program, manager, and division management through an audit report. The audit report may contain corrective action recommendations. If so, follow-up inspections may be required and should be performed by the QAC to ensure corrective actions are taken. The system audit ends with a review of the analytical reports and an audit of the records at the completion of the study.

The data audit, an important component of a total system audit, is a critical evaluation of the measurement, processing, and evaluation steps to determine if systematic errors have been introduced. During the data audit, the QAC, or his designee, will randomly select data to be followed through the analysis and data processing. The scope of the data audit is to verify that the data handling system is correct and to assess the quality of the data generated.

The data audit, as part of the system audit, is not an evaluation of the reliability of the data presentation. The review of the data presentation is the responsibility of the PM and the peer reviewer.

## 3.2 Corrective Action

Corrective action is the process that occurs when the results of an audit or quality control measurement are shown to be unsatisfactory, as defined by the data quality objectives or by the measurement objectives for each task. The corrective action process involves the PM, the TL and the QAC. In cases involving the analytical process, the corrective action also will involve the analyst. A written report is required on all corrective actions.

The PM and the TL will consult with appropriate staff having expertise in areas where difficulties are experienced and will propose solutions to situations requiring corrective action. Program management will be involved in the problem-solving discussions and may have input into final decisions.

There are two types of corrective actions:

Immediate corrective action is a quick response to improper procedures such as malfunctioning equipment. The need for such an action is usually identified by the analyst as a result of calibration checks and internal quality control sample analysis. The PM, who will be notified of the problem immediately, will then take and document appropriate action. The PM is responsible for and is authorized to halt the work if it is determined that a serious problem exists.

Long-term corrective action is used to prevent the recurrence of unanticipated problems. The need for such action may be identified by audits. The long-term corrective action steps consist of:

- Definition of the problem
- Investigation to determine the cause
- Determination of the appropriate corrective action
- Implementation of the corrective action
- Verification of the effectiveness of the corrective action by a follow-up inspection.

The PM is responsible for and is authorized to implement any procedures to prevent the recurrence of problems.

### **3.3 Reports to Management (C2)**

The project status will be reported to the PM on a weekly basis by the project staff. Any problems found during the analytical process requiring corrective action will be reported immediately by the project staff to the PM and the QAC through the investigation and corrective action documentation. The results of the in-phase inspection by the project or program management will be documented in the project files and reported to the QAC. In-phase inspections conducted by the QAC will be reported to management in the same manner as other audits.

Results of system audits, in-phase inspections, performance evaluations, and data audits conducted by the QAC will be routed to the PM and the TL for review, comments, and corrective action, and forwarded to management. An assessment of the data will be sent for management review. The performance evaluations, control issues, and corrective action responses covered by the audit reports will be reviewed and approved by the program manager, section manager, and division management. The results of all assessments, audits, inspections, and corrective actions for the project will be summarized and included in the quality assurance/quality control section in the final report.

The reporting requirements are a draft final report and a final report submitted as part of the contractual obligation. Electronic deliverables in the form of data tables will also be submitted.

### **3.4 Task 6—Project Report**

MRI will submit a draft report to include an Executive Summary, a description of data collected, data sources, methods and techniques employed, as well as findings, results, and recommendations. If the DEJF decides that the results support changes to AP-42, MRI will also provide draft and final version of any AP-42 sections to be revised along with background documents and appendices associated with such revisions. Such documents will include all experimental procedures, equipment used, and findings. Differences between the existing and proposed AP-42 emission factors will be thoroughly documented and explained. A final report will be submitted after review and approval by the DEJF.

## **Section 4.**

### **Data Validation and Usability (D)**

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#### **4.1 Data Review, Validation, and Verification Requirements (D1)**

The data analysis procedures to be used for this project are procedures that have been passed through several layers of validation in substantiating the performance of the method. The procedure for calculation of a raw particulate concentration requires a sample mass and an associated sampler flow rate. It should be noted that blank-corrected sample mass is considered quantifiable (and usable for concentration calculation) only if it equals or exceeds three times the standard deviation for the net weight gain of the field blanks.

The TL or designee will conduct an on-site spot check to assure that data are being recorded accurately. After the field test, the QAC or designee will check data input to assure accurate transfer of the raw data. The TL or designee will perform an independent check of any computer data reduction program through an independent hand-calculation of at least one test run.

For this project, all records will be evaluated for adherence to all procedures and requirements. The items that will be reviewed include:

- Gravimetric audit weighing for the assessment of the particulate data
- Calibration and calibration criterion checks
- Results of all blanks
- Validation of data process systems or procedures
- Traceability and sample tracking

Selected data will be reconstructed, including tracing the calibration back to the primary standards. Any software (spreadsheets) used to determine numerical values will be checked by hand calculating all intermediate and final results for one run by referring to original sources of data (i.e., field filter logs, filter weight logs, run sheets, look-up tables for volumetric flow controllers).

#### **4.2 Validation and Verification Methods (D2)**

The verification methods used to ensure that the data meets the quality control and measurement objectives (Table 1-1) are the internal technical assessment conducted by the PM and the TL and the peer review. In the data verification process, the project data are assessed against criteria specified in the method quality objectives and compliance with the tests plan, protocol, SOPs, and contractual requirements. The technical

assessment includes the evaluation of the data in an objective manner to ensure the correctness of the data. The results of these evaluations are determined by the adherence of the project to the test plans, protocols, and written instructions.

The verification of the data consistency is evaluated through the external quality audits by the QAC. The consistency is evaluated using the results from the field and laboratory quality control data and any samples noted in the sampling design as providing data that can provide a measurement of consistency. Additionally, the external quality audits will provide an assessment on the completeness of the data. The review of the data during the external quality audit and the project management assessment will allow quantification of the study's overall performance.

In the verification process, data that do not conform to the measurement objects, quality control criteria, or method criteria must be reviewed and assessed by the task leaders and PM. The nonconforming data will be investigated and addressed through the corrective action process as described in Section 3.2.

Once the verification process is completed and any required corrective action have been taken on all non-conforming data, the results are validated with respect to the data quality objectives for the project. The validation process will ensure that the field and laboratory system meets the project's needs as given in the data quality objectives. The data will be qualified based on the detection and degree of variability associated with the data. The relevancy of the results will be assessed with respect to the performance criteria used for making a decision based on all of the information obtained during the course of the project.

If the results from the validation process fail to fulfill the data quality objectives as cited in Section 1.4, the process is stopped and evaluated by the PM with the consultation of the WRAP. All nonconforming results must be assessed and reconciled before a final report may be issued.

### **4.3 Reconciliation With User Requirements (D3)**

The data generated during the field exercise will be evaluated with respect to the user requirements to estimate PM-10 and PM-2.5 emissions from fugitive dust sources. Recommendations for revisions to current emission estimation methods will be presented in the test report.

## Section 5. References

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1. U.S. EPA. Compilation of Air Pollutant Emission Factors. AP-42, Fifth Edition. Research Triangle Park, NC. September 1995.
2. Baxter, T. E, D. D. Lane, C. Cowherd, Jr., and F. Pendleton. "Calibration of a Cyclone for Monitoring Inhalable Particulates." *Journal of Environmental Engineering*, 112(3), 468. 1986.
3. Davies, C. N. The Entry of Aerosols in Sampling Heads and Tubes. *British Journal of Applied Physics*. 2:921. 1968.