QUALITY ASSURANCE PROJECT PLAN FOR THE UPPER GREEN RIVER WINTER OZONE STUDY 2015

Prepared for:

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By

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A Trinity Consultants Company

QUALITY ASSURANCE PROJECT PLAN
FOR THE UPPER GREEN RIVER
WINTER OZONE STUDY 2015

UGWOS 2015 QAPP APPROVAL

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SECTION 1.0 INTRODUCTION AND PROJECT OVERVIEW

This monitoring and quality assurance plan prepared for the Wyoming Department of Environmental Quality (WDEQ) Air Quality Division (AQD) provides the basis for the collection of air quality and meteorological data for the Upper Green River Winter Ozone Study (UGWOS) for the winter of 2015 (January 15 through March 31). While research in nature, the monitoring methods and objectives described in this plan are consistent whenever possible with U.S. Environmental Protection Agency (EPA) quality assurance guidance for the collection of air quality and meteorological data (US EPA 2008a and 2008b) and the most recent guidance for the collection of meteorological data for regulatory modeling applications (US EPA, 2000).

Over the past several years, high ozone events have been observed which have raised concerns regarding potential adverse health and ecological effects associated with monitored concentrations greater than the U.S. EPA's current eight-hour ozone standard of 0.075 ppm. Ozone formation in the Upper Green River Basin is unusual in that the highest concentrations have been recorded during the late winter and early spring (February to April) when sun angles are relatively low and temperatures are generally below freezing. This is in stark contrast to ozone exceedances in other areas, which occur during the warm summer months when abundant solar radiation and high temperatures act to increase precursor emissions and enhance the atmospheric reactions that result in ozone formation near the earth's surface (i.e., within the planetary boundary layer). Due to the pressing need to manage ozone air quality in the Upper Green River Basin and the limited amount of information available about the nature and causes of these unusual events, the WDEQ has funded comprehensive field studies during January through the end of March from 2007 to the current winter/early spring season (referred to as the Upper Green Winter Ozone Study or UGWOS). While meteorological conditions unfavorable to ozone formation encountered during the 2007 study period resulted in only limited monitoring, more favorable meteorological conditions during 2008 and 2011, and to a lesser degree during 2009, 2010, 2012, 2013, and 2014 resulted in several days of high ozone concentrations, including a large number of days in 2008 and 2011 when the 0.075 ppm Federal ozone standard was exceeded. Additional measurements have been planned for the winter of 2015. This QA plan addresses the 2015 monitoring effort.

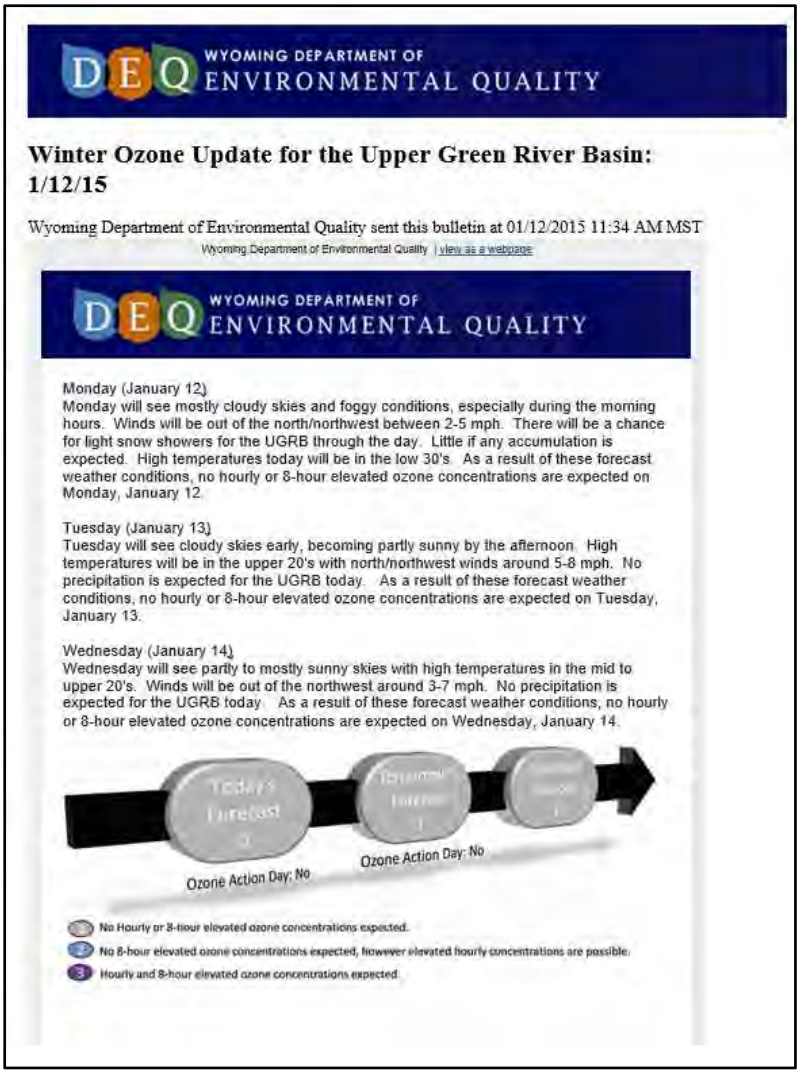
Similar to past years, data from the 2015 study will continue to be used to refine a conceptual model of ozone formation developed on the basis of prior year's studies of ozone formation. The conceptual model will be used along with the field data to develop accurate meteorological and air quality numerical simulations of the ozone events. Both the conceptual and numerical models will in turn be used to develop effective air quality management strategies needed to adequately protect public health and the environment in accordance with applicable State and Federal laws.

SECTION 2.0 SAMPLING PROGRAM DESCRIPTION

The sampling period for UGWOS 2015 will run from January 15, 2015 through March 31, 2015. Sampling that will be conducted for UGWOS during this period is described below.

2.1 Forecasting Protocol

The UGWOS effort for 2015 will not have an intensive operating period (IOP) component as in prior years. For 2015, MSI Trinity's meteorologist will assist WDEQ-AQD as requested in preparing the Daily Winter Ozone Update for the Upper Green River Basin bulletin. The MSI Trinity meteorologist will monitor weather conditions daily in order to be prepared to assist with, or as requested by the WDEQ-AQD to develop the ozone update. The ozone update for the Upper Green River Basin bulletin is posted on the WDEQ website at: http://deq.wyoming.gov/aqd/public-notices/air-air-quality-winter-ozone/. The bulleting is normally available by noon and covers the current day and the following two days. Figure 2.1 presents an example of this bulletin.



WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY

Winter Ozone Update for the Upper Green River Basin: 1/12/15

Wyoming Department of Environmental Quality sent this bulletin at 01/12/2015 11:34 AM MST

Wyoming Department of Environmental Quality | view as a webpage

WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY

Monday (January 12)
Monday will see mostly cloudy skies and foggy conditions, especially during the morning hours. Winds will be out of the north/northwest between 2-5 mph. There will be a chance for light snow showers for the UGRB through the day. Little if any accumulation is expected. High temperatures today will be in the low 30's. As a result of these forecast weather conditions, no hourly or 8-hour elevated ozone concentrations are expected on Monday, January 12.

Tuesday (January 13)
Tuesday will see cloudy skies early, becoming partly sunny by the afternoon. High temperatures will be in the upper 20's with north/northwest winds around 5-8 mph. No precipitation is expected for the UGRB today. As a result of these forecast weather conditions, no hourly or 8-hour elevated ozone concentrations are expected on Tuesday, January 13.

Wednesday (January 14)
Wednesday will see partly to mostly sunny skies with high temperatures in the mid to upper 20's. Winds will be out of the northwest around 3-7 mph. No precipitation is expected for the UGRB today. As a result of these forecast weather conditions, no hourly or 8-hour elevated ozone concentrations are expected on Wednesday, January 14.

Figure 2.1 Example Daily Winter Ozone Update

In developing the forecast, the current conceptual model of the meteorological conditions conducive to the formation of high ozone levels is used. The model is specific to the Pinedale-Jonah fields during the winter and early spring and is characterized by mostly clear skies, light winds, extensive snow cover and a stable atmosphere. These conditions occur during periods when the synoptic weather is dominated by high pressure over the western Rockies, Intermountain area and the northern Great Basin. The primary broad scale characteristics dominating the Green River basin during the high probability events are weak pressure gradients within the context of a subsidence-dominated air mass.

In an effort to formulate the conceptual model, the synoptic scale weather patterns prior to occurrences of escalated ozone values in the study area during the winters of 2005 and 2006 were examined. Practical experience from the previous UGWOS studies has provided further understanding of conditions leading to higher ozone concentrations. Although many different nuances of the general pattern were encountered, the basic characteristics of the conceptual model did emerge. Figures 2.2 through 2.5 present composite views of the 700 mb and 500 mb configurations for all of the days with surface 8-hour averaged ozone concentrations greater than 60 ppb in 2004 through 2006. Figure 2.2 shows the ridging pattern of the 500 mb height contours; Figure 2.3 presents the wind speed isotachs at 500 mb; Figure 2.4 shows the ridging pattern of the 700 mb height contours; and Figure 2.5 demonstrates that there was warmer air aloft just above the surface, indicating air mass subsidence.

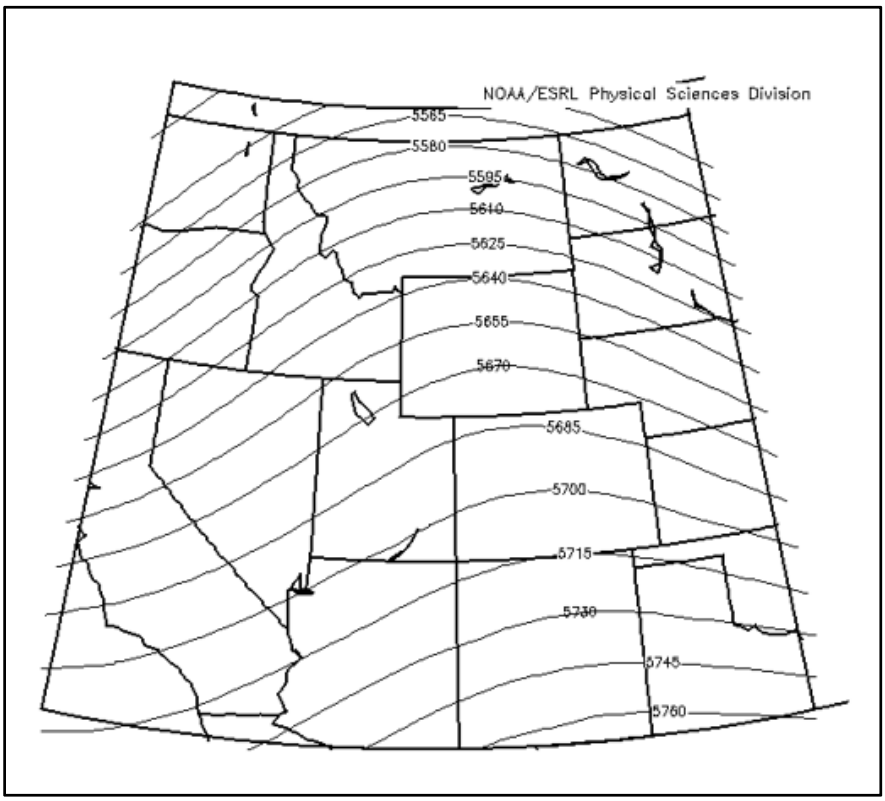


Figure 2.2 Composite 500 mb Heights during High Ozone Periods

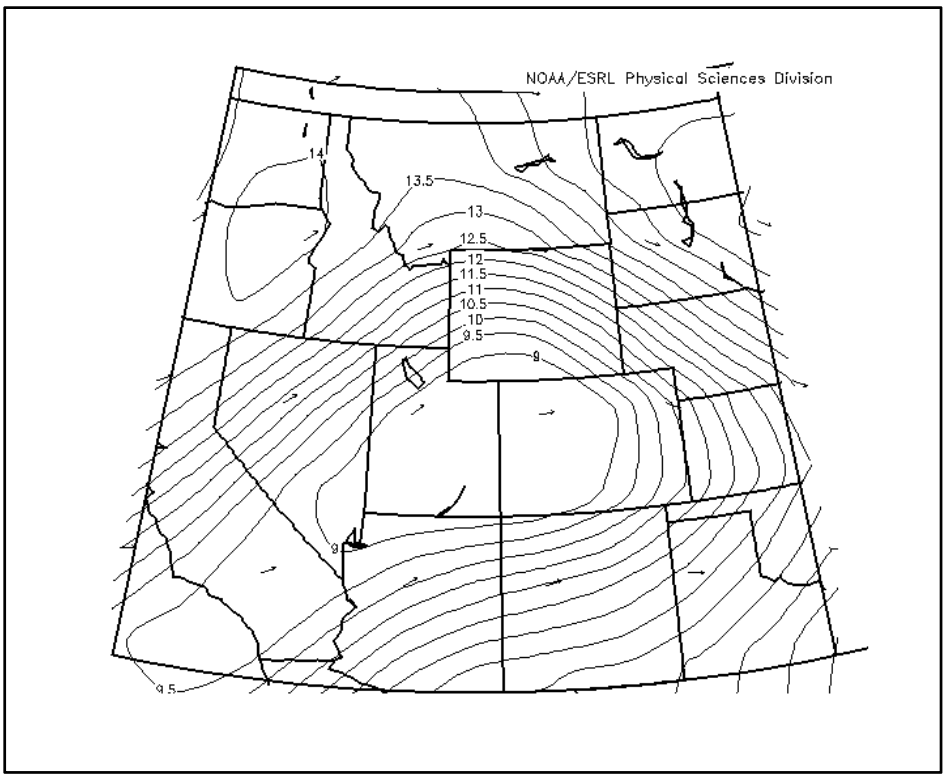


Figure 2.3 Composite 500 mb Winds during High Ozone Periods

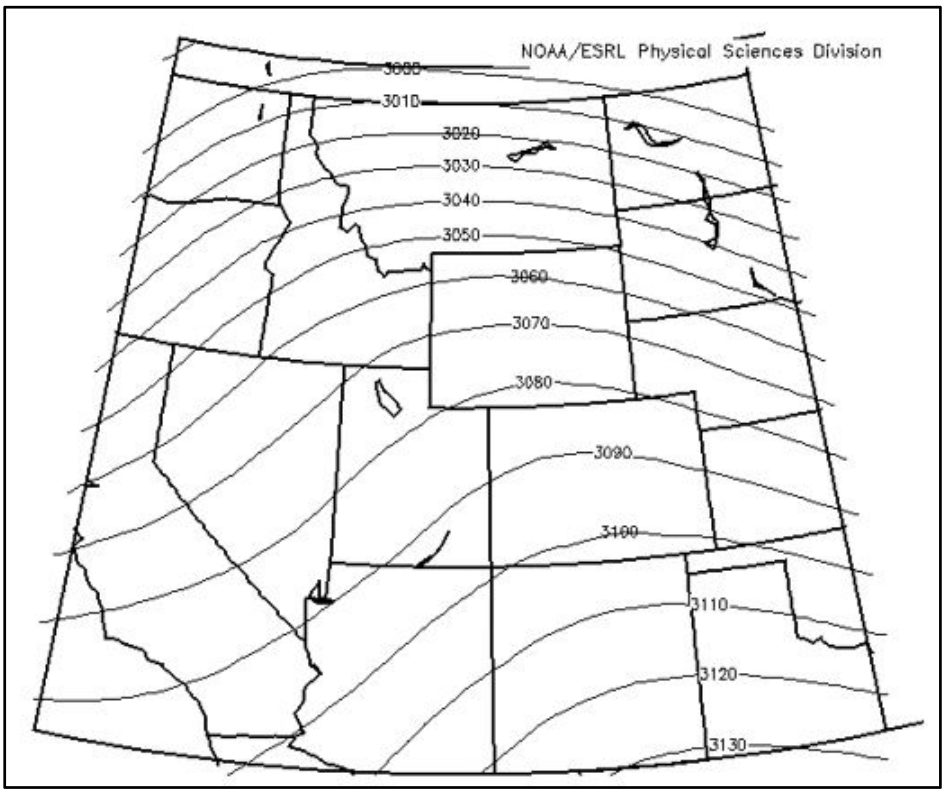


Figure 2.4 Composite 700 mb Heights during High Ozone Periods

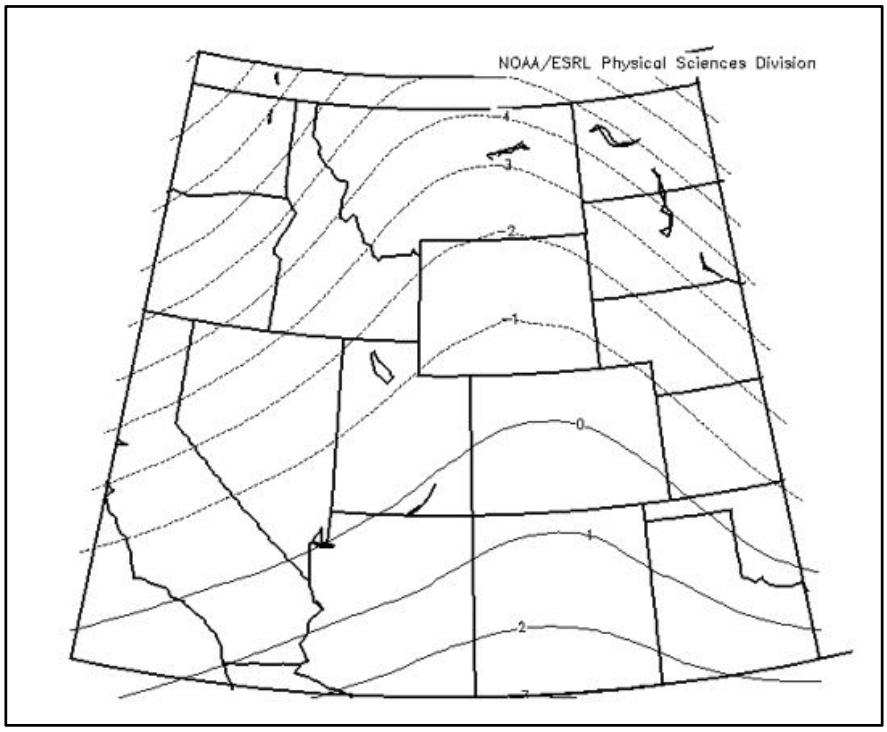


Figure 2.5 Composite 700 mb Temperature during High Ozone Periods

National Weather Service numerical synoptic-scale models such as the North American Mesoscale model (NAM), the Global Forecast System model (GFS), and the European model (ECMWF) coupled with regional NWS Forecast Discussion guidance, will provide the experienced WDEQ-AQD and MSI Trinity weather forecasters with the basis for daily long and medium range operational forecasts. Additional factors that appears to prove critical in operational forecasting is the presence of sufficient snow cover and the angle of the sun which when working together provide the strong UV radiation flux and enhanced low level stability that are needed for development of high ozone concentrations.

2.2 Continuous Measurements

Project-specific measurements to be continuously obtained over the complete field program period are presented below.

2.2.1 Mesonet Measurements

Surface wind speed, wind direction, and temperature measurements will be taken from at a three-site network mesonetwork (mesonet). These three sites are located at: Jonah, Mesa, and Paradise. In addition, each mesonet site will be equipped with a video camera, which will obtain images every 15 minutes. All sites will be equipped with cellular telemetry, allowing remote polling and real-time review of data. A snow stick will be installed at each site to give an estimate of snow depth at each of the sites. The snow sticks will be in prominent view of each of the camera locations.

2.2.2 VOC Canister Sampling

Speciated VOC measurements will be performed using the TO-14 canister sampling method with expanded analyte list; formaldehyde and acetaldehyde sampling will be performed using the TO-11 sampling method DNPH cartridges. VOC and DNPH sampling will be at five sites, Boulder, Big Piney, Mesa, Jonah and Paradise on sample days chosen by the WDEQ-AQD based on input from the forecasters. VOC will be sampled as integrated 3-hour samples. VOC samples will be collected using 6-liter SUMMA canisters connected to canister samplers owned by the WDEQ, and with the existing canister sampling system at Boulder and Big Piney. Carbonyl samples will be collected using DNPH-coated cartridges outfitted with ozone scrubbers and connected to constant flow pump systems over the same time period as the canisters. Samples will be collected on WDEQ chosen days, typically from 07:00 a.m. to 10:00 a.m. Thus, up to 12 samples will be taken at each of the sites over the course of the study. In addition, two (2) quality control samples will be collected per sampling event, including zero air contamination samples, duplicates, and field blank samples.

3.0 MONITORING SITE DESCRIPTIONS

As indicated in the previous sections, mesonet sites will be located at Jonah, Mesa, and Paradise. Canister samples will be also collected at Boulder and Big Piney. Figure 3.1 presents a map of the UGWOS site locations. Table 3-1 presents coordinates for each of the sites. Photographs of the sites can be found in Appendix A. Also included in Figure 3.1 and Table 3-1 are the locations of additional ozone monitoring sites in the study region.

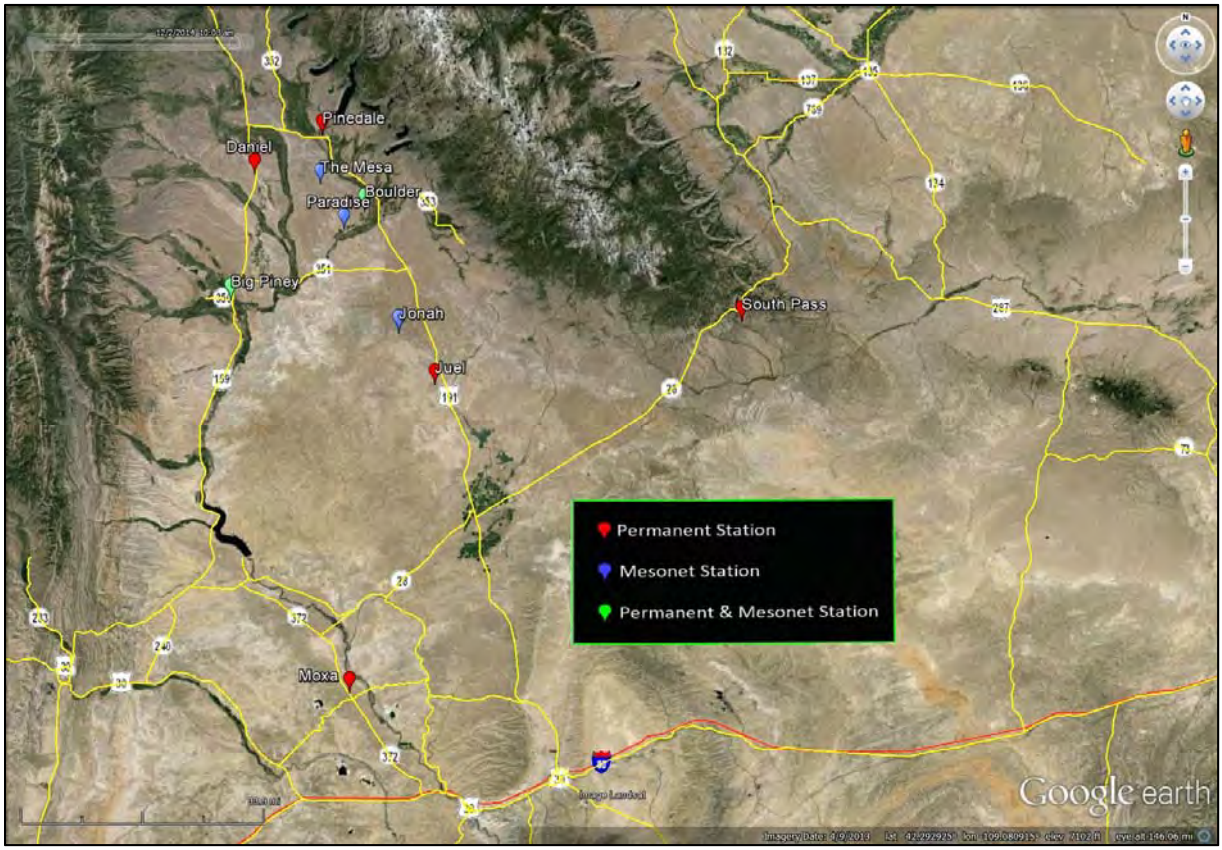


Figure 3.1. Map of UGWOS and Additional Ozone Monitoring Site Locations

Table 3-1 UGWOS 2015 Monitoring Locations

Site	Latitude	Longitude	Elevation (feet)
Mesonet Sites			
Jonah	42.47340	-109.6469	7,259
Mesa	42.78205	-109.8818	7,522
Paradise	42.68227	-109.8088	6,966
Existing Monitoring Sites			
Boulder	42.7188	-109.7529	7,078
Big Piney	42.4870	-110.0995	6,823
Daniel	42.7910	-110.0650	7,084
Farson	422.1184	-109.4541	6,619
Pinedale	42.8698	-109.8707	7,186
Juel Spring	42.3735	-109.5605	7,020
South Pass	42.5280	-108.7200	8,287
Moxa	41.7500	-109.7880	6,460

4.0 MONITORING EQUIPMENT DESCRIPTION

The following section describes the monitoring equipment that will be used for UGWOS 2015. Measurement Quality Objectives (MQOs) are presented for each of the monitoring methods.

4.1 VOC Sampling

WDEQ-owned VOC samplers were retrieved by MSI Trinity and bench checked prior to deployment. Figure 4.1 shows the sampler, with key components highlighted. These samplers are outfitted with a data logger that enables automatic start/stop operation so that samplers can be loaded with sampling media on the evening preceding a sampling event. Ambient air will be obtained from a ⅛" Teflon sample tube connected to a ¼ " stainless steel inlet tube, with the inlet positioned approximately two meters above ground level.

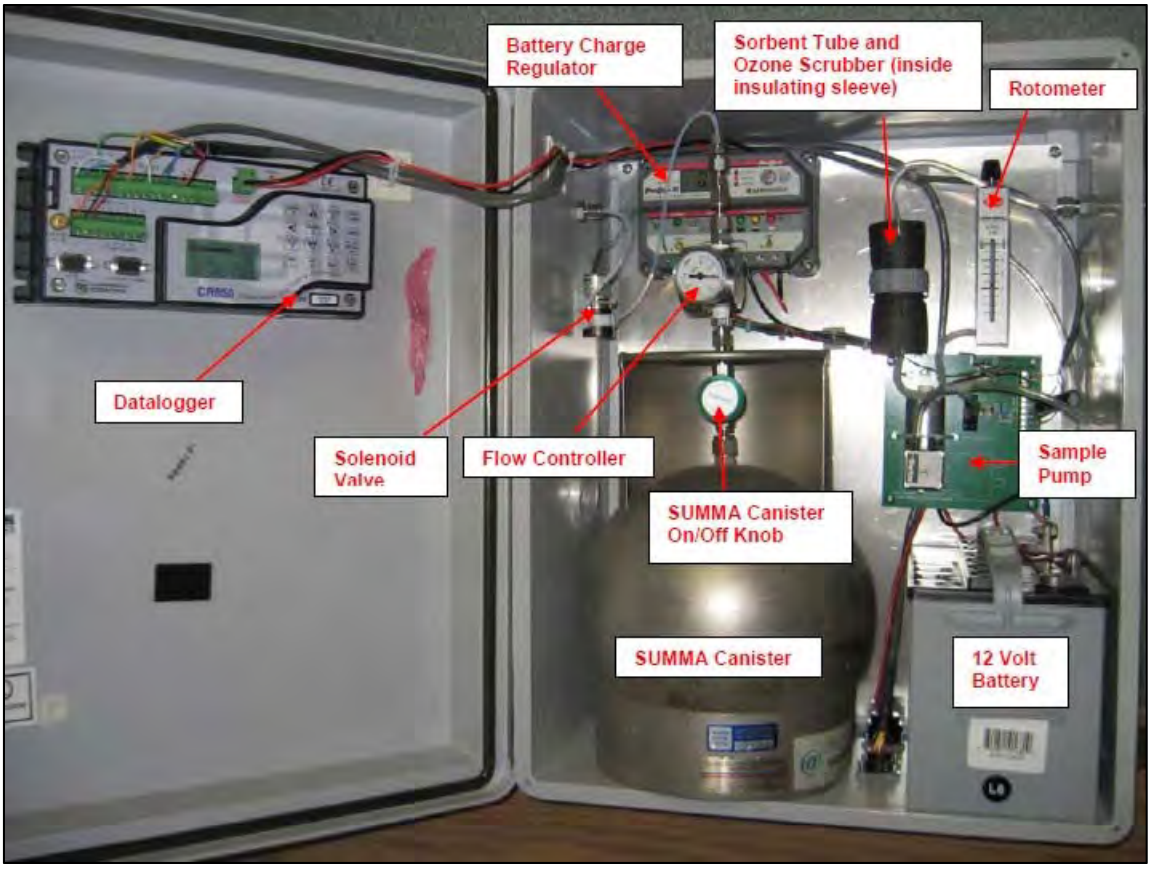


Figure 4.1 Canister Sampling System

Carbonyl measurements will be made by pulling ambient air at 1-2 LPM through DNPH cartridges with an ozone scrubber inserted upstream of the cartridge.

MSI Trinity's field technician will be responsible for loading and retrieving canisters and carbonyl cartridges into the samplers at each site, confirming sample run times, removing samples and filling out the affiliated documentation. Exposed sample media at the monitoring sites will be collected at the end of each intensive study day and sent to Environmental Analytical Service (EAS) laboratory for analysis. Field sample sheets will accompany samples and the required chain-of- custody documentation will accompany each shipment. Samplers will be cleaned prior to the start of the measurement program and tested for contamination.

VOC SUMMA canister samples will be analyzed using Method TO-14 with an expanded PAMS list of compounds listed in Table 4-1. Carbonyl samples will be analyzed using Method TO-11 for the compounds listed in Table 4-2. Analysis will be performed by EAS which is located in San Luis Obispo, CA.

Table 4-1 Target Compound List for EPA Method TO-14 Toxics in Air (Expanded for PAMS)

Ethene	2-Methylpentane	Ethylbenzene
Acetylene	3-Methylpentane	M,p-Xylene
Ethane	1-Hexene	Styrene
Propene	n-Hexane	o-Xylene
Propane	Diisopropyl ether	1-Nonene
i-Butane	3-Methylcyclopentene	n-Nonane
Methanol	Ethyl tert butyl ether	i-Propylbenzene
1-Butene	Methylcyclopentane	n-Propylbenzene
1,3-Butadiene	2,4-Dimethylpentane	a-Pinene
n-Butane	Benzene	3-Ethyltoluene
t-2-Butene	Dodecane	4-Ethyltoluene
c-2-Butene	Cyclohexane	1,3,5-Trimethylbenzene
Ethanol	2-Methylhexane	2-Ethyltoluene
3-Methyl-1-butene	2,3-Dimethylpentane	b-Pinene
Acetone	3-Methylhexane	1,2,4-Trimethylbenzene
i-Pentane	2-Methyl-1-hexene	n-Decane
1-Pentene	Tert amyl methyl ether	1,2,3-Trimethylbenzene
Isopropanol	2,2,4-Trimethylpentane	Indan
2-Methyl-1-butene	n-Heptane	d-Limonene
n-Pentane	Methylcyclohexane	1,3-Diethylbenzene
Isoprene	2,5-Dimethylhexane	1,4-Diethylbenzene
t-2-Pentene	2,4-Dimethylhexane	n-Butylbenzene
c-2-Pentene	2,3,4-Tirmethylpentane	1,4-Dimethyl-2-ethylbenzene
Tert butyl alcohol	Toluene	1,3-Dimethyl-4-ethylbenzene
2-Methly-2-butene	2,3-Dimethylhexane	1,2-Dimethyl-4-ethylbenzene
2,2-Dimethylbutane	2-Methylheptane	Undecane
Cyclopentene	4-Methylheptane	1,2,4,5-Tetramethylbenzene
n-Propanol	3-Ethyl-3-methylpentane	1,2,3,5-Tetramethylbenzene
Cyclopentane	3-Methylheptane	Naphthalene
Methyl tert butyl ether	2-Methyl-1-heptene	Total Petroleum Hydrocarbons
2,3-Dimethylbutane	n-Octane	Total non-Methane hydrocarbons
Sample: Composition Total Identified Paraffins, Isoparaffins, Aromatics, Napthlenes, Olefins, Oxygenates		

Table 4-2 Target Compound List for EPA Method TO-11 Volatile Organic Compounds

Compound
Formaldehyde
Acetaldehyde
Acrolein
Acetone
Propionaldehyde
Butyraldehyde
Methylethylketone
Benzaldehyde
Valeraldehyde
Cyclohexanone
Hexaldehyde

4.2 Mesonet Monitoring Sites

Three (3) mesonet monitoring sites located at Jonah, Mesa, and Paradise are included as part of the UGWOS 2015 sampling program. Each mesonet site consists of a three-meter tripod equipped with a wind speed and direction sensor, and a temperature probe. A photograph of a mesonet site is presented as Figure 4.2.

Figure 4.2 Photograph of Mesonet Site

Presented below is a description of the monitoring equipment that will be at each of the mesonet sites.

RM Young Model 05305 Wind Monitor AQ

For surface monitoring of wind speed and wind direction at the mesonet sites, R.M. Young 05305 Wind Monitor AQ wind speed and direction sensors will be utilized. The R.M. Young Model 05305 Wind Monitor AQ is made of UV-stabilized plastic with stainless steel and anodized aluminum fittings. Precision grade, stainless steel ball bearings are used. Transient protection and cable terminations are in a convenient junction box.

The wind speed sensor is a four blade helicoid propeller. Propeller rotation produces an AC sine wave voltage signal with frequency directly proportional to wind speed. Slip rings and brushes are eliminated for increased reliability. The starting threshold is 0.4 m/s.

The wind direction sensor is a rugged yet lightweight vane with a sufficiently low aspect ratio to assure good fidelity in fluctuating wind conditions. Vane angle is sensed by a precision potentiometer housed in a sealed chamber. With a known excitation voltage applied to the potentiometer, the output voltage is directly proportional to vane angle. A mounting orientation ring assures correct alignment of the wind direction reference when the instrument is removed for maintenance. The vane starting threshold is 0.5 m/s at 10 degrees displacement.

The sensors will be mounted on 3-meter tripods resulting in a measurement height of 3 meters. All sensors will be oriented to true north using either a professional transit adjusted for local declination, solar alignment.

Campbell Scientific 109-L Temperature Probe

Ambient temperature will be monitored using a Campbell Scientific 109 temperature probe. The 109-L Temperature Probe is a thermistor designed for use specifically with the CR200-series data loggers and has a measurement temperature range of -50° to +70°C.

The monitoring quality objectives for the supplemental surface wind and temperature measurements are presented in Table 4-3.

Table 4-3 Monitoring Quality Objectives

Wind Speed and Wind Direction	
Accuracy (instrument specifications)	
Horizontal Wind Speed	±(0.2 m/s + 5% of observed)
Horizontal Wind Direction	±5 degrees
Precision (performance checks)	
Horizontal Wind Speed	±0.2 m/s
Horizontal Wind Direction	±2 degrees
Output Resolution	
Horizontal Wind Speed	0.1 m/s
Horizontal Wind Direction	1 deg.
Starting Threshold	0.5 m/s
Temperature	
Accuracy (performance checks)	±0.5°C
Precision (performance checks)	±0.2°C
Resolution	0.1°C

Campbell Scientific CR850 Data Loggers

All data will be stored at each mesonet site using a Campbell Scientific CR850 data logger. Both 5-minute and 60-minute averages will be stored, though the 5-minute data will be validated and used to create 60-minute averages. GPRS cellular modems will be used to retrieve the data via a real-time data connection with attempts every 15 minutes.

StarDot Video Cameras

StarDot video cameras will be used to automatically obtain high resolution images from each of the sites every 15 minutes. These cameras produce 1.2 megapixel images and utilize an on-board web and FTP server to deliver images.

5.0 DATA REPORTING

5.1 Data Management Plan

A primary study objective of the UGWOS study is to produce an adequately validated data set from the field measurements that is well defined and documented, and available to researchers in a timely manner. The overall goal of the data management effort is to create a system that is straightforward and easy for users to obtain data and provide updates.

MSI Trinity will collect all measurements remotely on at least an hourly basis. Preliminary data will be posted on a near real-time basis on a password-protected UGWOS web site at http://ugwos.metsolution.com. Both five-minute and hourly averages will be stored in data acquisition systems. Five-minute data will be validated and used to calculate hourly averages. The data loggers are all equipped with internal memory that can store data for the duration of the study. Thus, if telemetry fails at a given site, data can be collected manually. All polled data are backed up at least daily, minimizing the chance of data loss. Camera images as well as daily forecasts will be displayed on the web site. Figures 5.1 and 5.2 are example graphics that will be presented on the internal website.

Each data provider will be responsible for reviewing and validating their collected data. The raw data will be validated to Level 1 as described in "The Measurement Process: Precision, Accuracy, and Validity" (Watson, 2001) before being submitted to the database. This includes flagging values for instrument downtime and performance tests, applying any adjustments for calibration deviation, investigating extreme values and applying appropriate quality control codes. Quality control codes used for UGWOS 2015 include simple validation codes as well as AQS null codes developed by the EPA and are presented in Table 5-1. Each data provider will be responsible for documenting the validation process so that it could be provided to the data manager and other analysts, if needed.

In addition, each data provider will be responsible for furnishing information regarding the monitoring equipment used in the field study and any additional site information to the data manager, as requested, to enhance the overall documentation of the study. In particular, participants will provide the Monitoring Quality Objective (MQOs) defining the quality of all data submitted as "valid." These MQOs contain the following:

- Accuracy
- Precision
- Lower quantifiable limit
- Resolution
- Completeness

If cases exist where data do not meet the primary MQOs but are still deemed useable and can be defined with a secondary set of MQOs, these additional MQOs and the dates to which they apply will also be submitted.

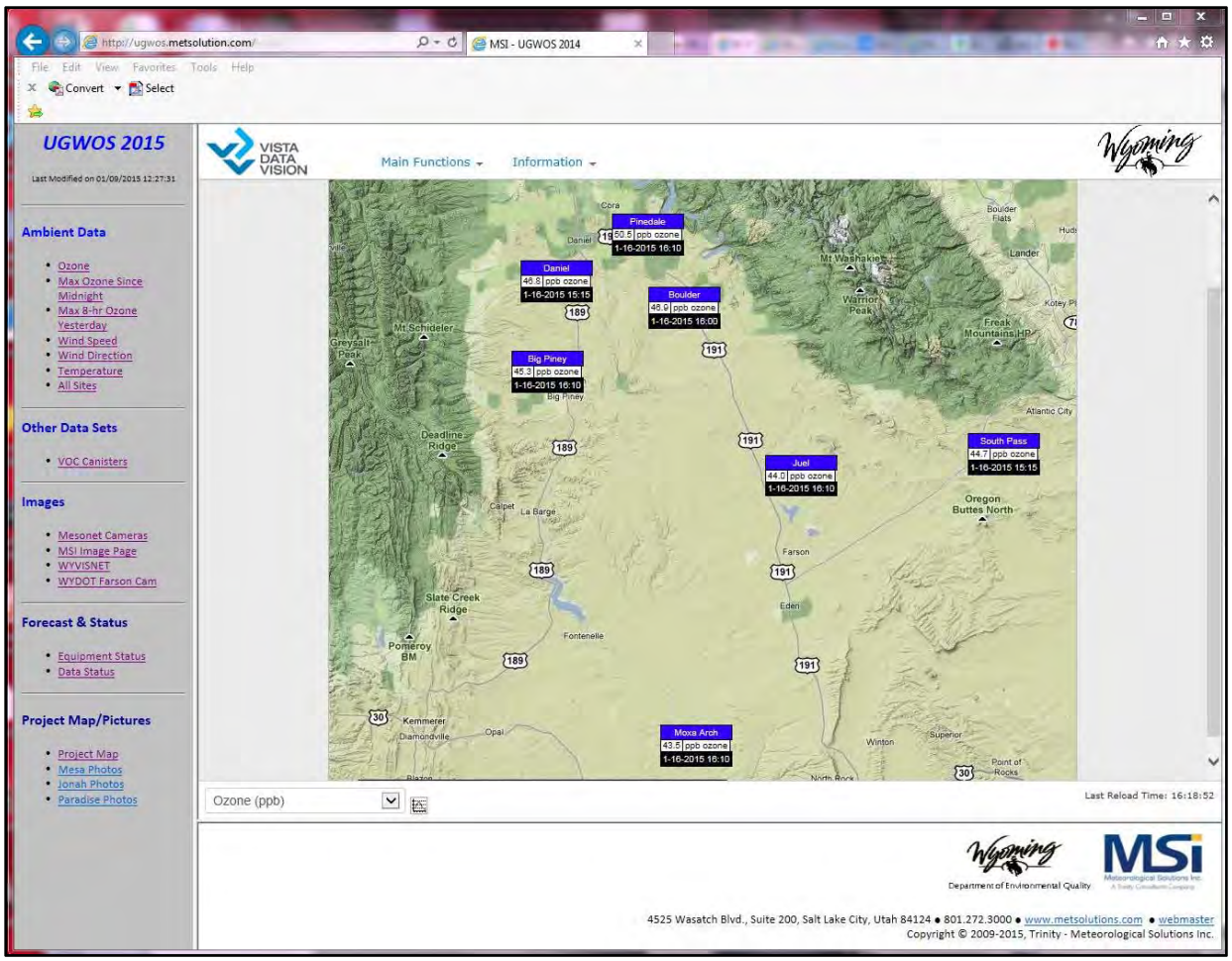


Figure 5.1 Ambient Ozone Map

Last Modified on 01/15/2015 12:42:02 UGWOS 2015

Equipment Matrix and Current Status

													Chemiluminescent			Photolytic			Total Reactive Nitrogen		
No.	Site Name	Site Operator	Camera	Canister	Carbonyl	WS	WD	TEMP	RH	THC	O3	PM	NO	NO2	NOX	NO	NO2	NOX	NO	NO2	NOY
1	Boulder	MSI	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2	Daniel	ARS	X			X	X	X	X		X		X	X	X						
3	Juel Spring	MSI	X			X	X	X	X		X		X	X	X						
4	Pinedale	MSI	X			X	X	X	X		X	X	X	X	X						
5	Big Piney	MSI	X	X	X	X	X	X	X		X	X	X	X	X						
6	Moxa	MSI	X			X	X	X	X		X	X	X	X	X						
7	South Pass	ARS	X			X	X	X	X		X	X	X	X	X						
8	Paradise Mesonet	MSI	X	X	X	X	X	X													
9	Jonah Mesonet	MSI	X	X	X	X	X	X													
10	Mesa Mesonet	MSI	X	X	X	X	X	X													

X	Operational
X	Suspect
X	Delayed Connectivity/Data Transfer
X	Inoperative
X	Not installed yet

Figure 5.2 Equipment Status

Table 5-1 Data Quality Control Codes

Flag	Description
V	Valid Data
U/ND	Non-Detect
M	Missing
I	Invalid
J	Estimated amount - Concentration below reporting limit (RL) and above minimum detection level (MDL)
U	Data which has not been validated - User is responsible for validation.
B	Compound was detected in batch method blank above reporting limit (RL)
E	This compound exceeds the calibration range for this sample volume
F	Higher detection limit because of matrix interference
AA	Sample Pressure out of Limits
AB	Technician Unavailable
AC	Construction/Repairs in Area
AD	Shelter Storm Damage
AE	Shelter Temperature Outside Limits
AF	Scheduled but not Collected
AG	Sample Time out of Limits
AH	Sample Flow Rate out of Limits
AI	Insufficient Data (cannot calculate)
AJ	Filter Damage
AK	Filter Leak
AL	Voided by Operator
AM	Miscellaneous Void
AN	Machine Malfunction
AO	Bad Weather
AP	Vandalism
AQ	Collection Error
AR	Lab Error
AS	Poor Quality Assurance Results
AT	Calibration
AU	Monitoring Waived
AV	Power Failure
AW	Wildlife Damage
AX	Precision Check
AY	Q C Control Points (zero/span)
AZ	Q C Audit
BA	Maintenance/Routine Repairs
BB	Unable to Reach Site
BC	Multi-point Calibration
BD	Auto Calibration
BE	Building/Site Repair

Table 5-1 Data Quality Control Codes (Continued)

BF	Precision/Zero/Span
BG	Missing ozone data not likely to exceed level of standard
BH	Interference/co-elution/misidentification
BI	Lost or damaged in transit
BJ	Operator Error
BK	Site computer/data logger down
BL	QA Audit
BM	Accuracy check
BN	Sample Value Exceeds Media Limit
DA	Aberrant Data

Once the data have been validated to Level 1, the data will be prepared for submittal to the database in a form that clearly defines the time reference, averaging period, parameter names and units. The time reference for the database is **local standard time (Mountain Standard Time)** and the averaging period reference will be standardized to **hour beginning (0 – 23)**. The data will be submitted as ASCII comma delimited text files or excel spreadsheet files, with data columns well defined to clarify site identification, parameters, instrumentation, units, and time reference.

Data will be submitted in a format similar to that of the final database structure, as outlined below. This basically has a second column for each measured value for an accompanying QC code. QC codes include simple validation codes as well as AQS null codes developed by the EPA.

5.2 Database Management Design

MSI Trinity will be responsible for assimilating the submitted data into an integrated relational Microsoft ACCESS database and is managing the data for subsequent distribution and analysis. The database will consist of both information and data files. The goal is to make the database very usable by data analysts and all participants.

The following describes the design for the database, which was similarly implemented during the UGWOS 2007 - 2014 field studies. The database includes an inventory spreadsheet file to help users track and ensure that all of the data were submitted and processed in a timely and consistent manner. All data files submitted will be examined to verify unique names for all sites, instruments, and parameters so that no orphan or duplicate records exist in any of the tables. A system is in place for identifying the version and or modification date of all data files. All files are backed up daily.

The data have the following file format:

Surface Hourly Meteorological Data

SITE, DATE, HOUR, WS, WS_QC, WD, WD_QC, TP, TP_QC, and any additional met parameters and QC codes, if collected.

Ozone 8-hour averaged data

SITE, DATE, HOUR, O3_8HR, O38HR_QC

Hourly Surface Air Quality data

SITE, DATE, HOUR, OZONE, O3_QC, NO, NO_QC, NOx, NOx_QC, NOy, NOy_QC, PAN, PAN_QC and any additional air quality parameters if collected and QC codes.

VOC Data

VOC canisters and carbonyl cartridges will be collected during IOPs. The canister data is analyzed using the TO-14 method and the carbonyl cartridges using the TO-11 method by EAS. Data files are formatted in a similar format to what is uploaded into the database. VOC data will be presented in two data tables. VOC will have individual compounds presented by canister sample and sample date. A second table in the database will have a summary of compound classifications.

The data will be formatted into the final database with the following unit configurations and naming conventions:

- Parts per billion (ppb) for O_3, NO, NO_2, and NO_x
- Meters per second for wind speed (as a general rule, metric units will be used)
- Degrees Celsius for ambient temperature
- Watts/m^2 for radiation
- Micrograms per cubic meter, parts per billion by volume, and parts per billion by Carbon for VOC canister data
- SITE = Alpha-numeric site code identifier
- DATE = (MM/DD/YY)
- HOUR= Nearest whole begin hour (HH) (MST)
- TIME, START_TIME or END_TIME = Time stamp of data (HH:MM:SS) (MST)
- HEIGHT = Elevation in meters above MSL
- QC_CODE, WS_QC, WD_QC, O3_QC, etc =
- "V" (valid), "M" (missing), "I" (invalid), "S" (secondary MQOs)
- NOTES = any additional information

The Level 1 data files along with the documentation files will be available for download on an FTP server.

5.2 Data Reporting

Files of all data collected during the study will be transmitted to WDEQ-AQD by June 15, 2015. MSI Trinity will review the validated data collected during the field study and prepare descriptive summaries in a report format for delivery to WDEQ-AQD. MSI Trinity will prepare summaries of air quality and meteorological conditions during the study period.

In addition, MSI Trinity will prepare more detailed descriptive analyses of the air quality and meteorology measured during any high ozone events during the study period. As part of the Level 1 data validation procedures, MSI Trinity will carefully examine all of the measurements. This process typically provides insight into the critical processes that determine the extent of pollution loading such as atmospheric stability, wind shear (low-level jets, etc), layers aloft, and boundary layer development (growth rate, peak mixing heights), including the nocturnal boundary, convective boundary, and residual layer. The meteorology leading up to and during periods with high ozone levels and the diurnal behavior of ozone aloft during these periods will be characterized.

Supporting the analyses discussion, products that will be produced in this phase of the study include but are not limited to:

1. Time-series plots of continuous measurements such as ozone, ambient temperature, radiation;
2. Wind roses at the surface;
3. Pollution roses at the surface; and
4. Summary tables of 1-hour and 8-hour averaged ozone as well as statistical summaries showing hourly averages and maximums.

A final report will be prepared presenting:

- The above-mentioned information and associated analyses in an easy to comprehend format.
- A summary of field operations. A measure of the associated data capture rates will be included. Problems encountered during the field operations will be discussed.
- Details of the database design including descriptions of the metafiles; field descriptors; and the accuracy, precision, lower limits, resolution, and completeness of each measurement.

A draft version of the report will be provided to WDEQ-AQD by July 15, 2015. Voluminous tables and figures will be incorporated into electronic appendices as appropriate. All report materials will be made available via a secure FTP transfer site.

Section 6.0 QUALITY ASSURANCE PROGRAM

6.1 Project Management

Mr. George Wilkerson will serve as overall project manager. Mr. Casey Lenhart will serve as the Field Operations Manager for the study. He will be responsible for coordinating and verifying corrective action for any measurement-related problems. While it is not anticipated that the scope of the monitoring effort will change over the relatively short duration of the effort, any changes will result in a revised version of this QAPP. Ms. Linda Conger is responsible for the writing and distribution of the QAPP. Revisions will be distributed based on the distribution list at the beginning of this document.

Study personnel responsibilities and contact information are presented in Table 6-1. An organizational chart for UGWOS 2015 is provided in Figure 6.1.

Table 6-1 Project Responsibilities and Contact Information

Name	Organization	Key Responsibilities	Phone Numbers
Cara Keslar	Wyoming DEQ	Contract Manager	(307) 777-8684 (307) 286-2383 (cell)
Adam Deppe	Wyoming DEQ	Forecasting	(307) 777-8754
Steve Mugg	Wyoming DEQ	Quality Assurance Audits	(307) 777-7352
George Wilkerson	MSI Trinity	Project Manager	(801) 272-3000 Ext. 304
Dan Risch	MSI Trinity	Forecasting	(801) 272-3000 Ext. 306
Casey Lenhart	MSI Trinity	Field Manager, Reporting	(801) 272-3000 Ext. 307 (801) 979-7874 (cell)
Linda Conger	MSI Trinity	Quality Assurance Coordinator	(801) 272-3000 ext. 305
Brian Olsen	MSI Trinity	Data polling Data processing and validation, Reporting	(801) 272-3000 Ext. 311
Scott Adamson	MSI Trinity	Database and Data Validation, Reporting	(801)-272-3000 Ext. 302
Mike Peterson	MSI Trinity	Field Technician - VOC Canister Sampling	(801)-272-3000 Ext. 310 (801)-450-8706 (cell)
Adam Lenkowski	MSI Trinity	Field Technician - VOC Canister Sampling	(801)-272-3000 Ext. 309 (801)-419-2882 (cell)
Tyler Ward	MSI Trinity	Field Technician - VOC Canister Sampling	(928) 814-3926 (cell)
Isaac Legare	MSI Trinity	Field Technician - VOC Canister Sampling	(801) 272-3000 ext. 316 (801) 520-2867 (cell)

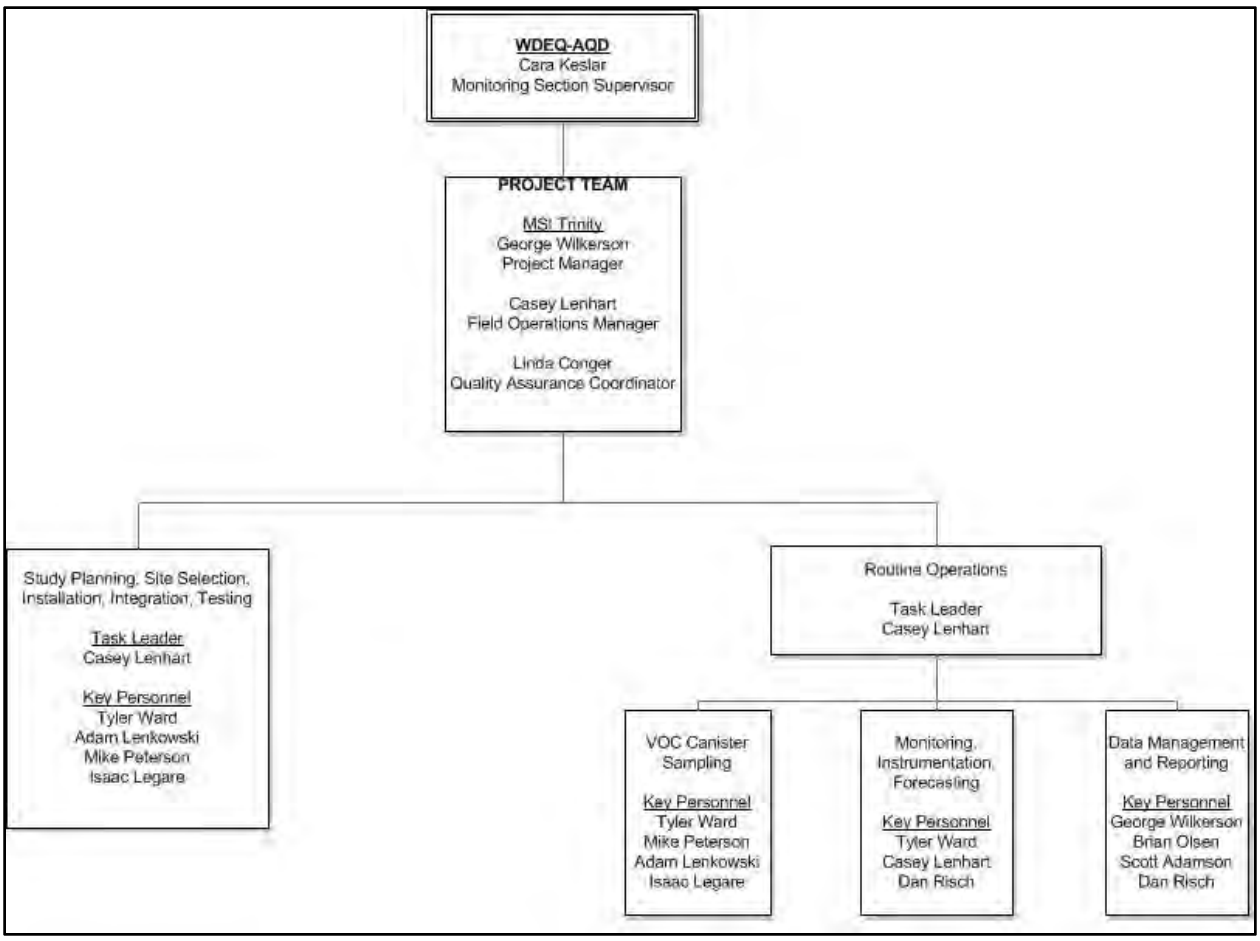


Figure 6.1 Organizational Chart

6.2 Data Quality Objectives

Specific measurement quality objectives have been presented for each measurement in Section 4 of this document. The overall objectives for the collection of valid data will be as follows:

- Air quality data - 80% of the possible data
- Meteorological data - 90% of the possible data

For the above calculation, data lost during calibrations, maintenance or audits are considered invalid.

6.3 Assessment and Oversight

As part of the quality assurance program, detailed quality control procedures have been implemented to assess and maintain control of the quality of the data collected. All equipment will undergo complete checkout and acceptance prior to the start of monitoring on January 15, 2015. This checkout will occur during the weeks prior to the start of monitoring, as well as during setup and installation of the equipment. Standard operating procedures (SOPs) for measurements will be developed for key monitoring activities. SOPs can be found in Appendix B.

A summary of key elements of the QC program for each measurement is presented below:

VOC Canister Sampling Systems

Tripod mounted portable VOC canister sampling systems will be flushed with ultrapure air and checked for contamination prior to the start of the UGWOS 2015 study. VOC canisters will be installed in each system, allowed to sample ultrapure air through the system inlet, and sent to the analytical laboratory for analysis to confirm that systems are free of contamination.

Calibrations

The purpose of a calibration is to establish a relationship between the ambient conditions and an instrument's response by challenging the instrument with known values and adjusting the instrument to respond properly to those values.

All meteorological sensors will be calibrated at the beginning and end of the study. Wind speed sensors will be calibrated using an R.M. Young constant rpm motor simulating wind speeds at several points across the sensor's operating range. Wind direction sensors will be calibrated by checking responses in a least 90° increments. Temperature sensors will be calibrated using a water bath and a certified thermometer.

The calibration method for each of the air quality and meteorological variables is summarized in Table 6-2.

Table 6-2 Calibration Methods for the Monitored Variables

Measurement Variable	Calibration Method
Wind Speed	Rotational rate using a selectable speed anemometer drive
Wind Direction	Alignment using true north and linearity with a directional protractor
Temperature	Water bath comparisons to a certified transfer standard

6.4 Data Validation

All data collected for UGWOS will be validated to Level 1 validation (see Section 5). As part of the validation effort, participant's data will be evaluated to verify that they meet the stated MQOs. If data clearly do not meet MQOs, they will be removed from the database as invalid data. If, however, data miss meeting the primary MQOs in a definable way to the point where the data are still considered useful, secondary MQOs will be assigned to the data in question. This use of secondary MQOs will be specifically documented in metafiles associated with the data.

7.0 REFERENCES

United States Environmental Protection Agency (2008): Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II: Part I, Ambient Air Quality Monitoring Program Quality System Development. Document EPA-454/B-08-003. Office of Air Quality Planning and Standards.

United States Environmental Protection Agency (2008): Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV, Meteorological Measurements. Document EPA – 454/B-08-002. Atmospheric Research and Exposure Assessment Laboratory, Research Triangle Park, North Carolina.

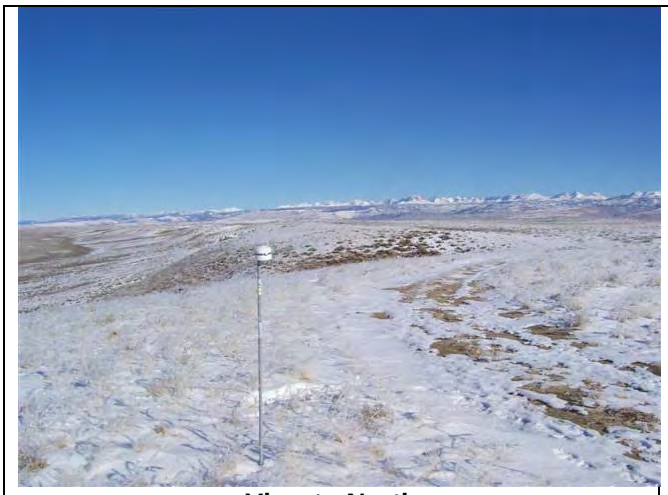
United States Environmental Protection Agency (1999): EPA Requirements for Quality Assurance Project Plans. Document EPA QA/R-5. U.S. EPA Quality Staff Interim Final Report, Research Triangle Park, North Carolina. November.

United States Environmental Protection Agency (2000). Meteorological Monitoring Guidance for Regulatory Modeling Applications. Document EPA-454/R-99-005. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

Watson, J.G., B.J. Turpin, and J.C. Chow (2001). The measurement process: Precision, accuracy, and validity. In *Air Sampling Instruments for Evaluation of Atmospheric Contaminants,* 9th ed., B. Cohen, Ed. American Conference of Governmental Industrial Hygienists, Cincinnati, OH, in press.

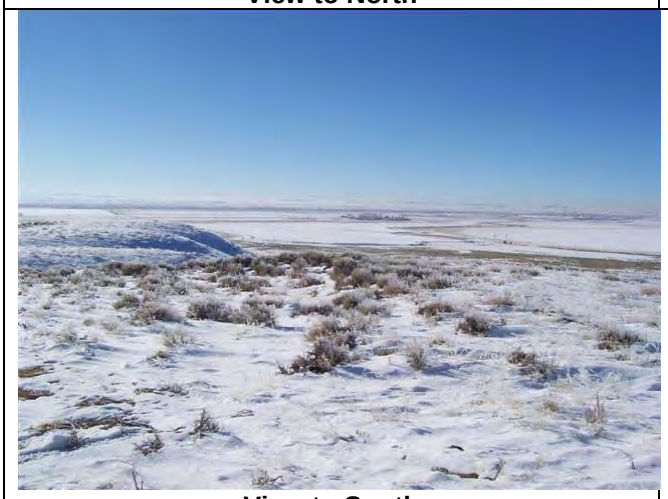
APPENDIX A

Site Photographs

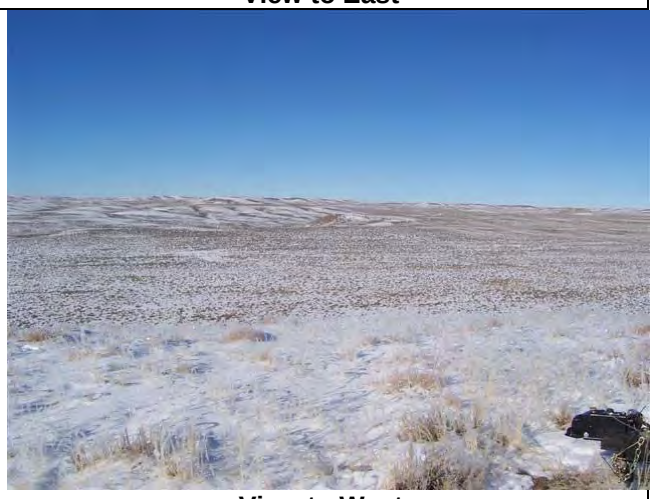


View to North

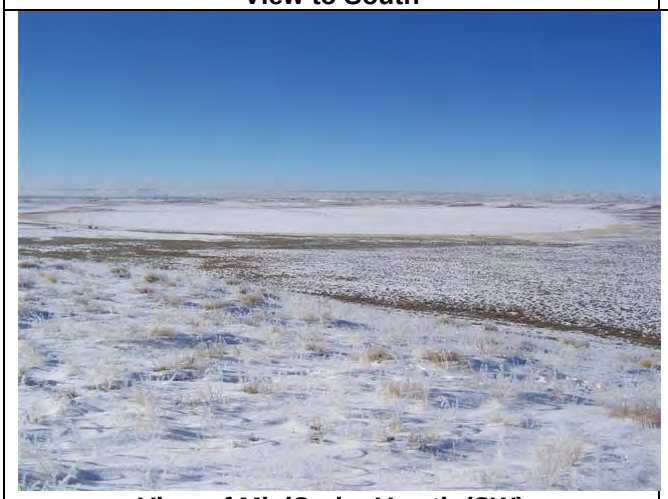
View to East



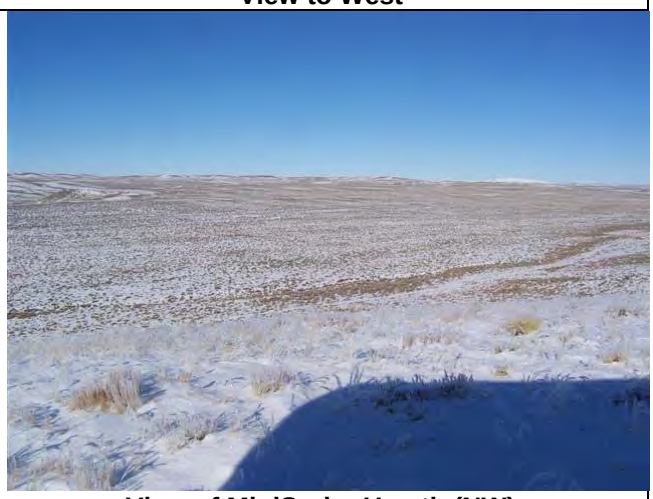
View to South



View to West



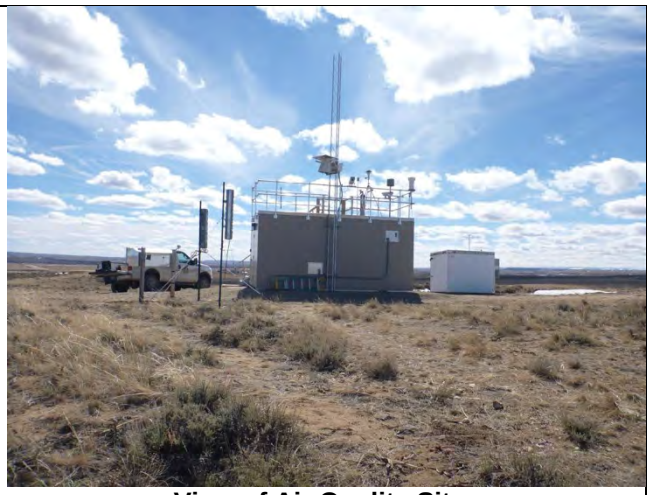
View of MiniSodar V path (SW)



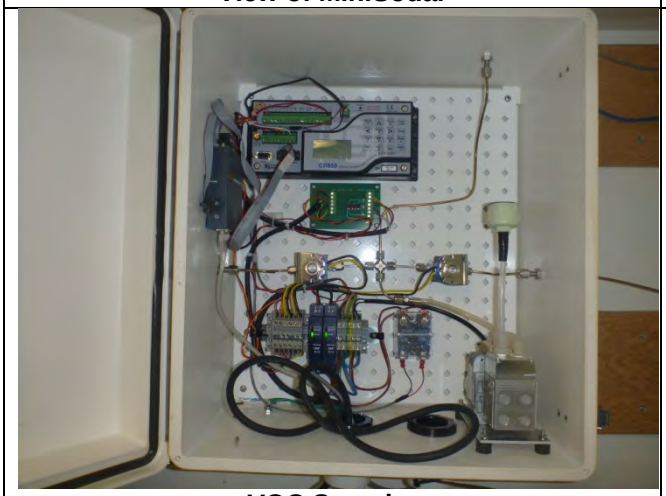
View of MiniSodar U path (NW)

Boulder Site

View of MiniSodar



View of Air Quality Site

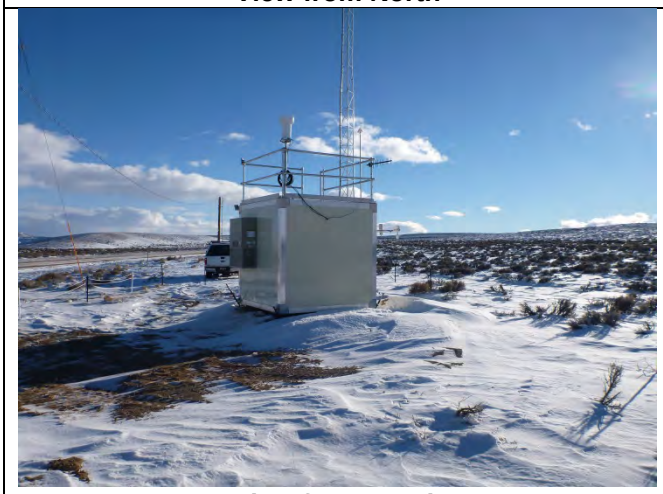


VOC Sampler

Boulder Site

View from North

View from East



View from South

View from West

Big Piney VOC Sampling

View from Jonah to North

View from Jonah to East

View from Jonah to South

View from Jonah to West

Air Quality Analyzers

Jonah Site

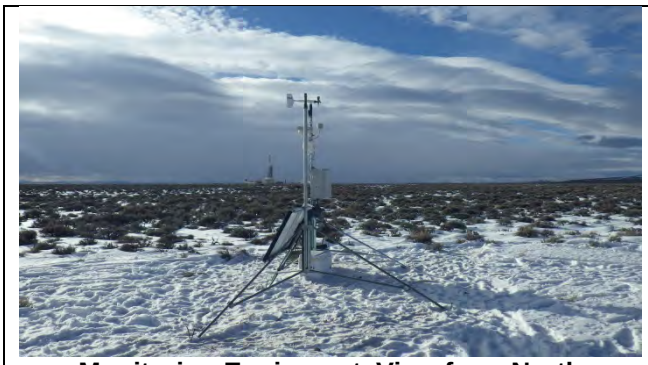
Monitoring Equipment, View from North

View from East

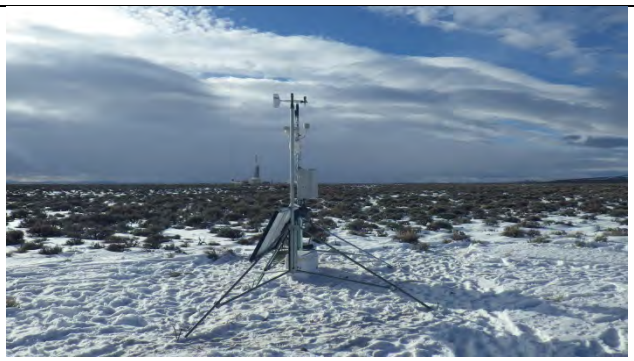
View from South

View from West

Paradise Site



Monitoring Equipment, View from North

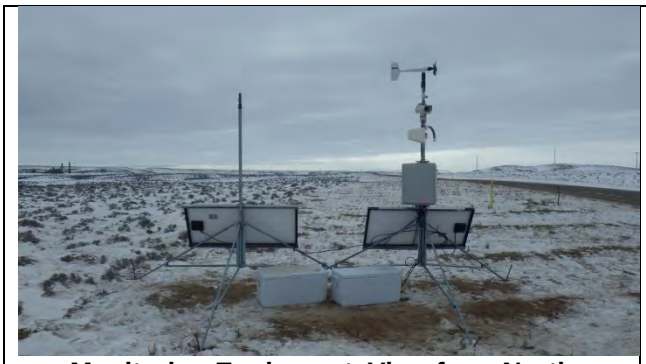


View from East

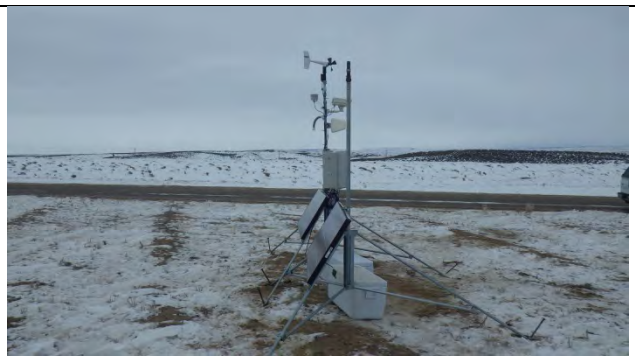
View from South

View from West

Mesa Site

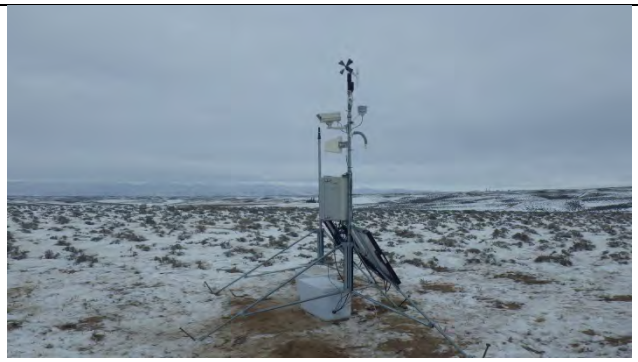


Monitoring Equipment, View from North



View from East

View from South



View from West

Warbonnet Site

APPENDIX B

Standard Operating Procedures

Meteorological Solutions Inc. A Trinity Consultants Company	**STANDARD OPERATING PROCEDURE**	Title: Sub-atmospheric Pressure Canister Sampling – Time-Integrated Samples Using Sampling System
		No: SOP 92 / Page: 1 of 2
		Revision No: 1 / Effective Date: 01/13/2015 08/07/2012 Rev. 0
Approval:	Date:	Concurred By:

This procedure describes collection of time-integrated ambient air samples in evacuated stainless steel SUMMA canisters to be submitted for subsequent analysis of target compounds at a central laboratory.

Equipment

1. Chain-of-Custody documentation.
2. Stainless steel canisters prepared for sampling at an approved laboratory.
3. Flow controllers capable of maintaining a constant flow rate over a sampling period of up to 24 hours.
4. Vacuum/pressure gauge.
5. Field sampling data sheets.
6. Wrenches.
7. Sampling system with data logger-controlled solenoid to automatically start and stop canister sampling.

Sampling Procedure

1. Ensure the canister valve is closed.
2. Remove the brass, screw-on cap from the upper valve of the stainless steel canister.
3. Connect the pressure gauge to the canister, open the canister valve, record the start pressure, and shut the valve.
4. Place canister inside sampling unit and connect the flow controller to it.
5. Connect the 1/8-inch sampling tube in the sampling system to the flow controller.
6. Open the upper valve of the clean evacuated canister by turning counter-clockwise.
7. Allow the data logger-controlled solenoid to start the sampler at the prescribed time (0700 MST).
8. Record the information on the form below. Any abnormalities surrounding the sample collection event should be recorded on the form.
9. The datalogger-controlled solenoid will stop the sample at the prescribed time (1000 MST).
10. After the sample has stopped, retrieve the canister from the system. First, close the canister valve by turning clockwise and remove the flow controller.
11. Connect the pressure gauge to the canister, open the valve, record the stop pressure, close the valve, and remove the pressure gauge.
12. Replace the brass, screw-on cap onto the upper valve of the stainless steel canister.
13. Put the stainless steel canister back into the shipping carton.
14. Put the sample collection form into the shipping carton.

15. Bring the canister back to the Pinedale project base for shipment to the analytical laboratory.
16. Ship to the analytical laboratory with chain-of-custody documentation.

MSI
Meteorological Solutions Inc.
A Trinity Consultants Company

Canister Sampling
Field Data Sheet

A. General Information

Site Location:
Sampler ID:
Operator:

B. Sampling Information

Canister ID:
Sample ID Number:
Start Date:
Stop Date:
Start Time:
Stop Time:
Canister Start Pressure:
Canister Stop Pressure:

C. Additional Notes

Meteorological Solutions Inc. A Trinity Consultants Company — **STANDARD OPERATING PROCEDURE**	Title: Carbonyl Sampling - Three Hour	
	Number: SOP 131	Page: 1 of 2
	Revision No: 2	Effective Date: 01/13/2015 12/31/2014 (Rev 1)
Approval:	Date:	Concurred By:

This procedure describes collection of ambient air carbonyl samples in DNPH cartridges using sampler pumps to draw air through the cartridge at approximately 2 liters per minute for three hours. Samples are then submitted for subsequent analysis of target compounds at a central laboratory.

Equipment

1. DNPH cartridges
2. Ozone scrubbers compatible with the cartridges
3. Sampling form
4. Chain-of-Custody documentation
5. Sampler pump

Sampling Procedure

1. Sampling pumps are interfaced with a datalogger or timer set to run at the following times: (0700-1000).
2. Using clean disposable gloves, remove a DNPH cartridge and ozone scrubber from packaging, remove the end plugs from the cartridge and insert into the scrubber.
3. Insert the ozone scrubber end on to the stainless steel barbed fitting located on the intake sampling tube bulkhead.
4. Connect the Luer-lok fitting on the tygon tubing to the DNPH cartridge (yellow) to make a connection with the pump.
5. Fill out the sample form and make a sample label by writing in the sample I.D. (e.g.,BOL022820140700).
6. Connect flow gauge (BIOS/rotameter) to sample inlet. Manually turn on control port and record flow rate.
7. Reconnect sample line inlet.
8. After three-hour sample has been taken, disconnect sample line inlet, and repeat Step 6.
9. Using clean disposable gloves remove the DNPH cartridge and ozone scrubber from the system and discard the scrubber. Replace the end caps in the DNPH cartridge.
10. Place the DNPH cartridge in the white envelope with aluminized interior. Fold over and seal with a label containing the sample I.D.
11. Place the completed sampling form and sealed cartridge envelope in a plastic bag and place in the cooler with blue ice.
12. Transport carbonyl samples in the cooler on ice for shipment to the analytical laboratory. Store in a refrigerator until ready to ship.
13. Ship to the analytical laboratory in a cooler with ice and chain-of-custody documentation.

Carbonyl Sampling Form

A. General Information

Site Location (BOL, PIN, JON):
Sampler ID:
Operator:
Shipping Date:

B. Sampling Information

Sample Number:
Load Date/Time (0400 only):
Date (Start);
Date (Stop):
Start Time:
Stop Time:
Flow Rate:
Abnormalities: