QUALITY ASSURANCE PROJECT PLAN

for the

UPPER GREEN RIVER WINTER OZONE STUDY - 2014

Prepared for

Wyoming Department of Environmental Quality

State of Wyoming
Department of Environmental Quality, Air Quality Division
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UGWOS 2014 QAPP APPROVAL

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SECTION 1

INTRODUCTION AND PROJECT OVERVIEW

This monitoring and quality assurance plan 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 2014, sponsored by the Wyoming Department of Environmental Quality (WDEQ). While research in nature, the monitoring methods and objectives described in this plan are consistent whenever possible with 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).

High ozone events observed in this area over the past several years have raised concerns regarding potential adverse health and ecological effects associated with monitored concentrations greater than the U.S. Environmental Protection Agency's ozone standard (currently set at an 8-hour average concentration 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 currently available about the nature and causes of these unusual events, the WDEQ funded a comprehensive field study (the Upper Green Winter Ozone Study or UGWOS) which was conducted during the late winter – early spring seasons of 2007 through 2013. 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 and 2013 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 2014. This QA plan addresses the 2014 monitoring effort.

Similar to past years, data from the 2014 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

SAMPLING PROGRAM DESCRIPTION

The sampling period for UGWOS 2014 will run from January 15, 2014 through March 31, 2014. Sampling that will be conducted for UGWOS during this period is described below.

2.1 FORECASTING PROTOCOL

The UGWOS effort for 2014 will have an intensive operating period (IOP) component. As in prior years, the UGWOS team will continue to provide ozone forecasts throughout the study period to assist the WDEQ in identifying potential high ozone periods.

The current conceptual model of the meteorological conditions conducive to the formation of high ozone levels in the Pinedale-Jonah fields during the winter and early spring 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 2.1 through 2.4 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 2-1 shows the ridging pattern of the 500 mb height contours; Figure 2.2 presents the wind speed isotachs at 500 mb; Figure 2.3 shows the ridging pattern of the 700 mb height contours; and Figure 2.4 demonstrates that there was warmer air aloft just above the surface, indicating air mass subsidence.

National Weather Service numerical synoptic-scale models such as the North American Mesoscale model (NAM) and the Global Forecast System model (GFS), coupled with regional NWS Forecast Discussion guidance, will provide the experienced MSI and AQD weather forecasters with the basis for daily long and medium range operational forecasts. An additional factor that appears to prove critical in operational forecasting is the presence of sufficient snow cover to provide the strong UV radiation flux and enhanced low level stability needed for development of high ozone concentrations. Local observations will provide this information on a day-to-day basis.

Forecasts for Air Quality Division's (AQDs) 2014 UGWOS ozone monitoring project will be issued by the MSI project meteorologists each morning. Once the forecast is completed it will be emailed to project participants by 10:00 MST each morning, seven days a week. The forecast will be finalized on a form containing three sections. The first section will be a synopsis of the current weather features that will affect the study area over at least the next 48 hours. The second section will contain a detailed short-term forecast out through day three. This forecast contains a discussion of temperature, wind, precipitation and sky conditions, and will also emphasize parameters that are of specific interest to the study, as appropriate, such as high pressure ridge location, inversion development, and snow cover. At the end of this section there will be a discussion on the expected ozone development during this period. The third section is an outlook that will cover days four through seven. This outlook will be similar in content to the second section with only the time frame changing.

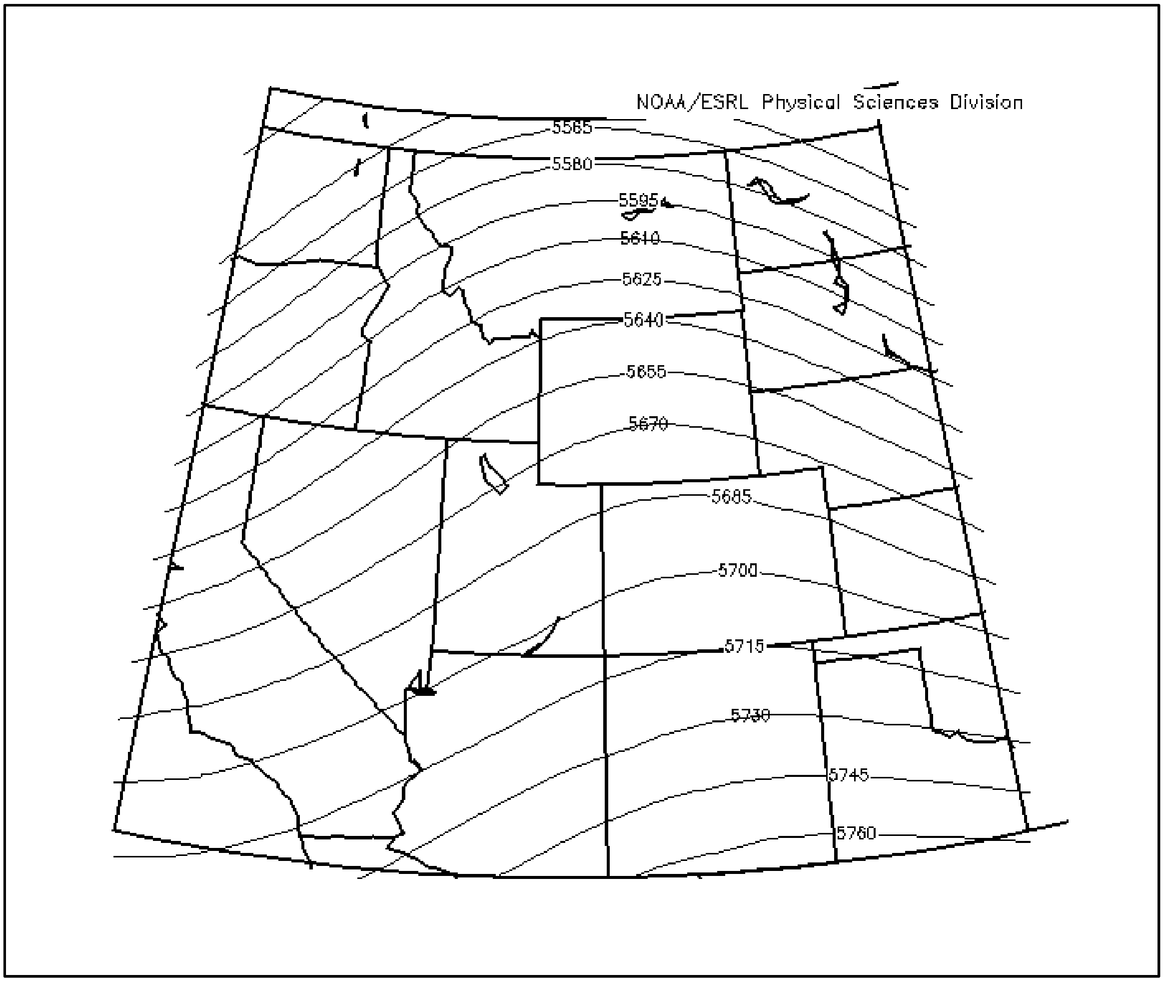

Figure 2.1 Composite 500 mb Heights During High Ozone Periods

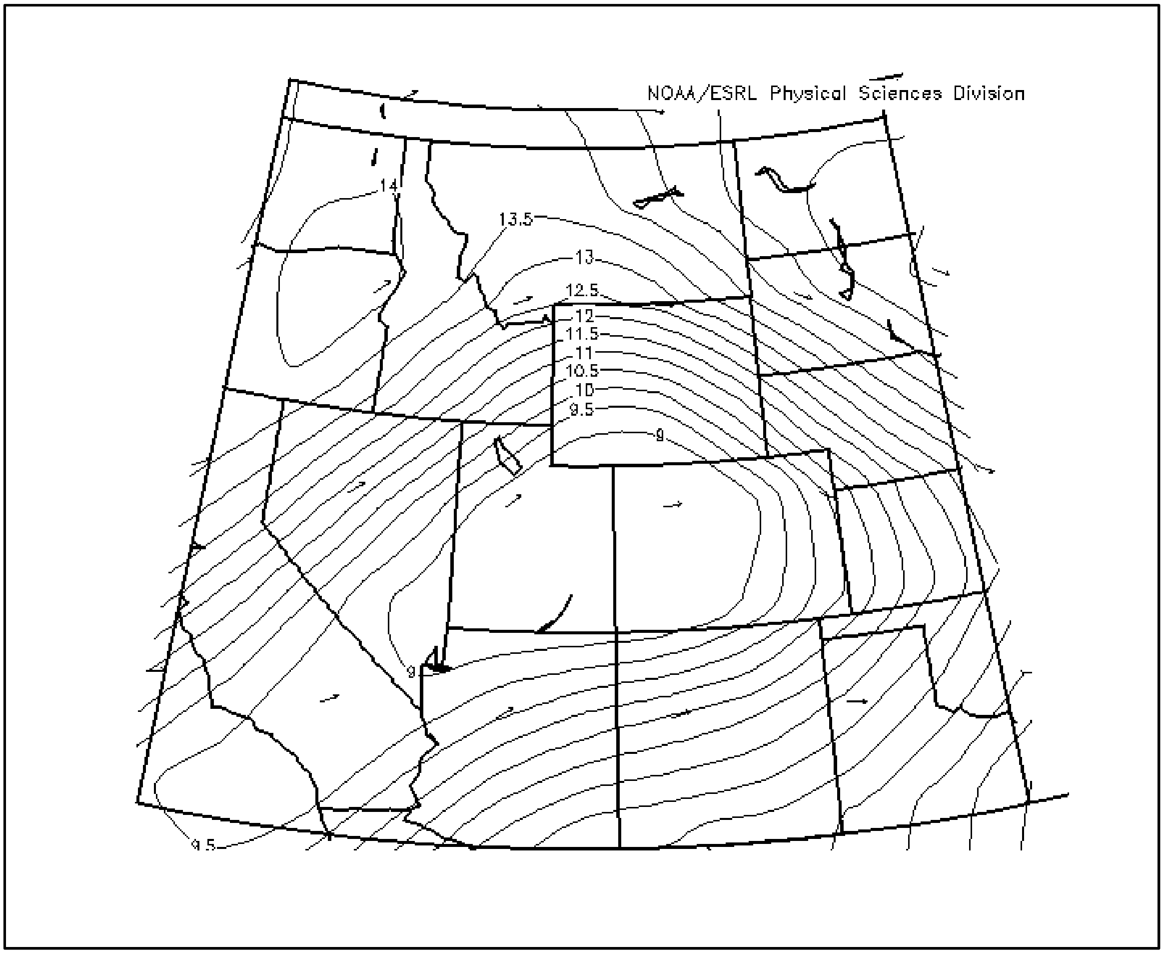

Figure 2.2 Composite 500 mb Winds During High Ozone Periods

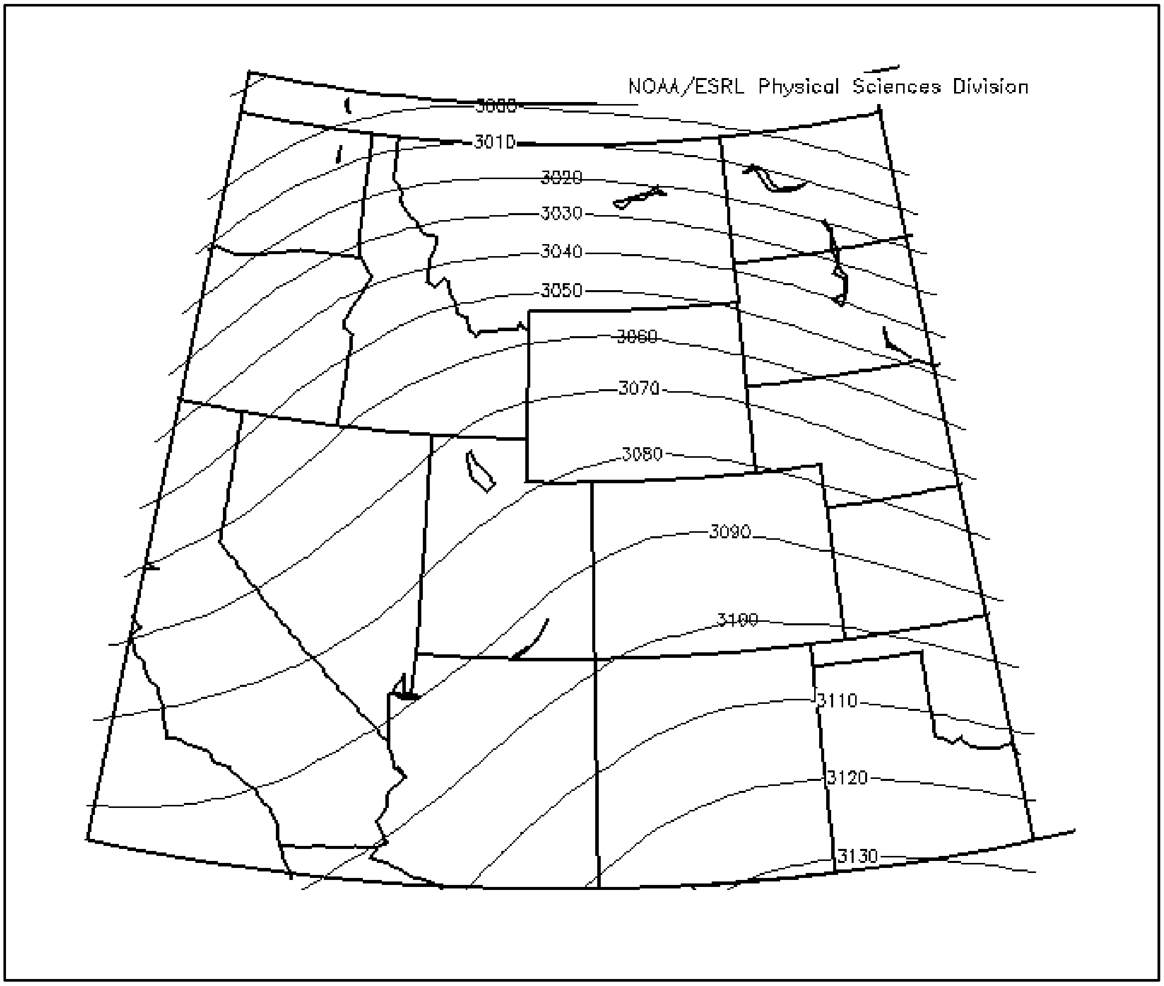

Figure 2.3 Composite 700 mb Heights During High Ozone Periods

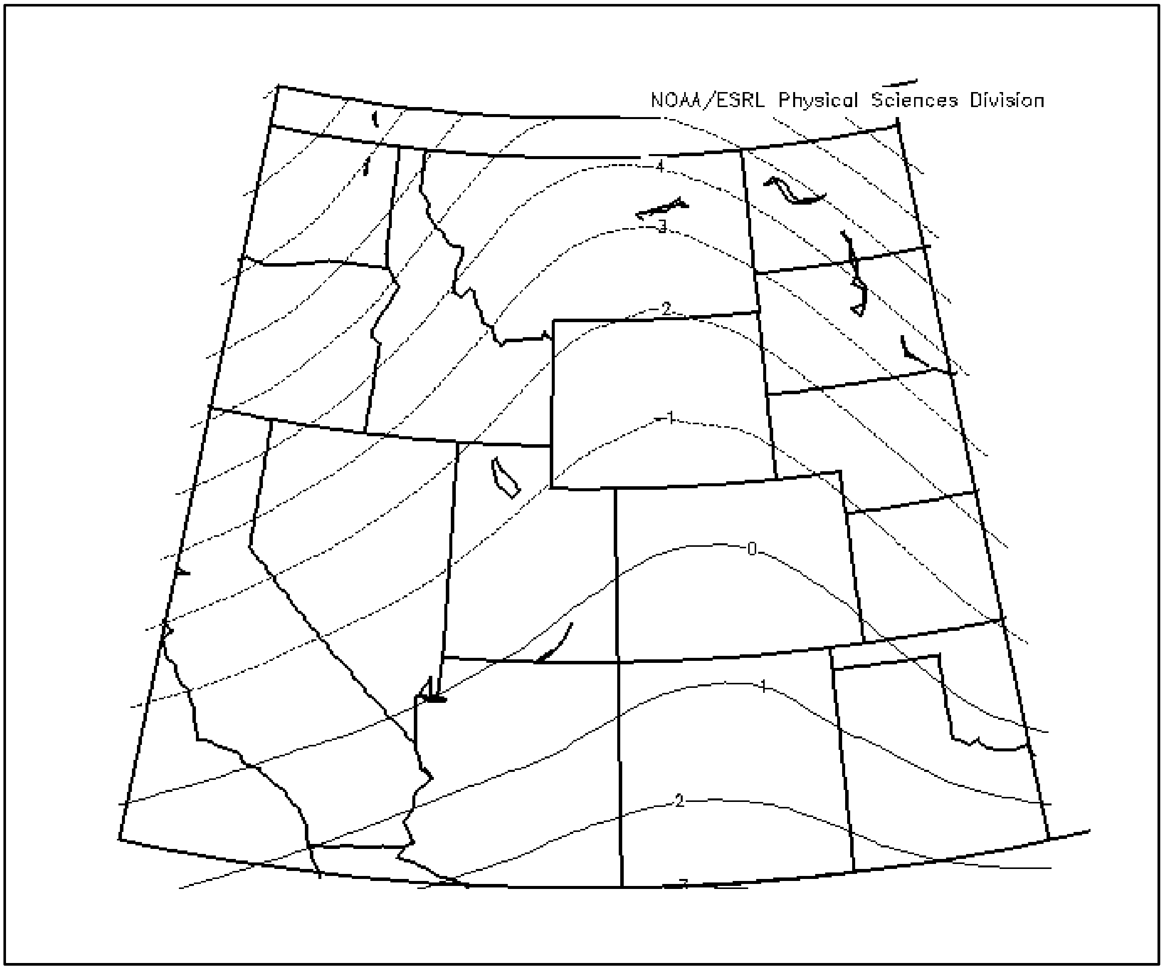

Figure 2.4 Composite 700 mb Temperature During High Ozone Periods

2.2 CONTINUOUS MEASUREMENTS

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

2.2.1 Super Mesonet Measurements

Surface ozone, wind speed, wind direction, and temperature measurements will be taken from a 3-site super mesonetwork (mesonet). 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.

The mesonet 2B ozone analyzers will operate continuously over the course of the study and routine performance checks of the analyzers will be conducted approximately once per week. Their operation on-site will be checked using a 2B ozone generator and zero-scrubber, with any zero and span deviations noted. As in previous UGWOS field programs, MSI will provide an on-site technician who will be stationed in the project area for the duration of the field season. The technician will provide field support and routine calibrations for the monitoring measurements for the Jonah site and the mesonet sites, and will deploy/retrieve VOC samples at the Jonah, Juel Spring, Big Piney, Boulder and mesonet sites (see below). He will also be available to troubleshoot issues at all AQD sites in the study area (Daniel, Boulder, Pinedale, Juel Spring, Big Piney, South Pass and Farson meteorological tower). The field technician will also be available to assist with UGWOS and AQD audits during the study period.

2.2.2 Ozone and NO/NO_x Measurements in the Jonah Area

Continuous ozone and oxides of nitrogen will be performed at a location within the Jonah Field utilizing a WDEQ air monitoring trailer. Sampling at the Jonah trailer will include continuous measurement of ozone, oxides of nitrogen, wind speed, wind direction, temperature and pressure. The site will also be equipped with a video camera, providing 15-minute images. A datalogger and cellular telemetry will be supplied to retrieve data from the site on an hourly basis. The site will be polled every 15 minutes to update data and post to project website. A snow stick will be installed to give an estimate of snow depth in the monitoring area. MSI will be responsible for the air quality and meteorological measurements, including routine checks, data validation, and database management.

2.2.3 SODAR Upper Level Winds

For the 2014 monitoring effort, the WDEQ MiniSodar (Sodar) will be maintained at the existing WDEQ monitoring site at Boulder. Both surface winds and winds aloft will be measured continuously. The Sodar is equipped with a battery bank, solar panels and a backup generator, providing continuous measurements without the need of AC power. However, the chosen site for operations does include available AC power. Remote communications is made possible with a cellular modem. All data will be posted in near real-time on a web page as well as archived data posted automatically on a FTP server. These Sodar data can be reviewed remotely, as necessary.

The WDEQ will service the Sodar, as necessary. T&B Systems will review the data on a daily basis, validate the wind data, and evaluate the collected data during the field effort, both in real-time and after the program is over. This additional evaluation is being conducted to determine what can be learned from measured parameters such as the vertical wind speed (W) and sigma-W, and how this information can be used to both help forecast the events and to help understand the mechanisms that control the mixing out of the shallow mixed layer.

2.3 INTENSIVE MEASUREMENTS

During periods when high ozone levels are forecast, additional intensive measurements will be initiated. Up to 10 IOP days over the course of two IOP periods are budgeted for this study. IOP days will be identified using forecast information and consultation with WDEQ AQD. The key component of the IOPs is the collection of vertical profiles of ozone and meteorology profiles and VOC and carbonyl samples, as described below.

2.3.3 Tethered Sounding Operations

Vertical profiles and aloft measurements of ozone, temperature and relative humidity will be initiated daily during IOPs at 2 sites (Boulder and Jonah). Additional soundings may be considered at Big Piney based on review of data within the study area. The first sounding will be taken at 9:00 to characterize the stable period of the diurnal cycle. Measurements will be ongoing thereafter through 16:30 to characterize the daytime boundary layer. The anticipated schedule is as follows:

- 0900 – 0930 Up/down sounding
- 0930 – 0945 Review data from sounding
- 0945 – 1015 Maintain balloon at constant level of interest, based on review
- 1015 – 1030 Up/down sounding
- 1030 – 1045 Review data from sounding

- 1045 – 1115 Maintain balloon at constant level of interest, based on review
- Repeat pattern until . . .
- 1615 – 1630 Complete day's operation with final up/down sounding

The EC-cell ozone sampler will be compared with the EPA designated equivalent analyzer, which will be simultaneously operating at each sounding site each time the balloon is elevated and retrieved. Balloon tethering height will be determined using the recorded altitude in the sonde GPS system for the MSI system and will be calculated using an onboard pressure sensor in the T&B Systems tethersonde.

It should be noted that on the first day of an IOP, there will be preparation time required to prepare the balloon and line assembly. Thus, the first sounding will be delayed until midmorning. At the completion of each sampling day, the balloons will be tethered at the ground.

It will be up to the tether balloon operator to determine when flying conditions become impractical due to higher winds. In these conditions, the balloon will be brought to the ground and secured until lower wind speeds allow further flights.

Tethered sounding sites will be manned by MSI and T&B Systems.

2.3.3 VOC Sampling

VOC sampling will be conducted at the Boulder, and Big Piney sites, as well as at the UGWOS-specific Jonah air quality site and the three mesonet sites. VOC will be sampled as integrated 3-hour samples. VOC samples will be collected using 6-liter SUMMA canisters connected to canister samplers previously used by the WDEQ for the Pinedale air toxics study conducted in 2009/2010 and with the existing canister sampling system at Boulder. 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 IOP days from 0700-1000. Thus, up to 10 samples will be taken at each of the sites over the course of the study. In addition, five (5) quality control samples will be collected at each site, including zero air contamination samples, duplicates, and field blank samples.

2.4 SUPPLEMENTAL MONITORING AND DATA COLLECTION

Archiving of NOAA Products

Archiving of selected NOAA data products will occur on a daily basis. The items that will be archived for the period from January 15 through March 31, 2014 are listed below:

- 00Z and 12Z surface and upper air maps for 700 mb, 500 mb and 850 mb. (Also readily available from on-line archives)
- All rawinsonde sites in the United States for both 00Z and 12Z time periods. (Also readily available from on-line archives)
- Visual and IR, US east and west satellite images twice per day. (Also readily available from on-line archives)

In addition to the above, the following data are currently archived on the web and are available for analysis:

- Snowpack - available at NOAA's National Operational Hydrologic Remote Sensing Center
- Total Column Ozone - A web site from NASA provides historical ozone global charts, and Dobson Unit measurements for any latitude/longitude on any particular day.
- Local Camera Images - The current local camera images from Daniel, Juel, Boulder and Pinedale can be viewed on line at the WDEQ or UGWOS web sites, and there is also a two week image archive on the WDEQ site which consists of an image at 9:00, 12:00, and 15:00 MST each day. Archived images can also be requested from Trinity Consultants. Images from the Jonah Field and the three mesonet sites will be transferred every 15 minutes and posted on the UGWOS website.

SECTION 3

MONITORING SITE DESCRIPTIONS

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.

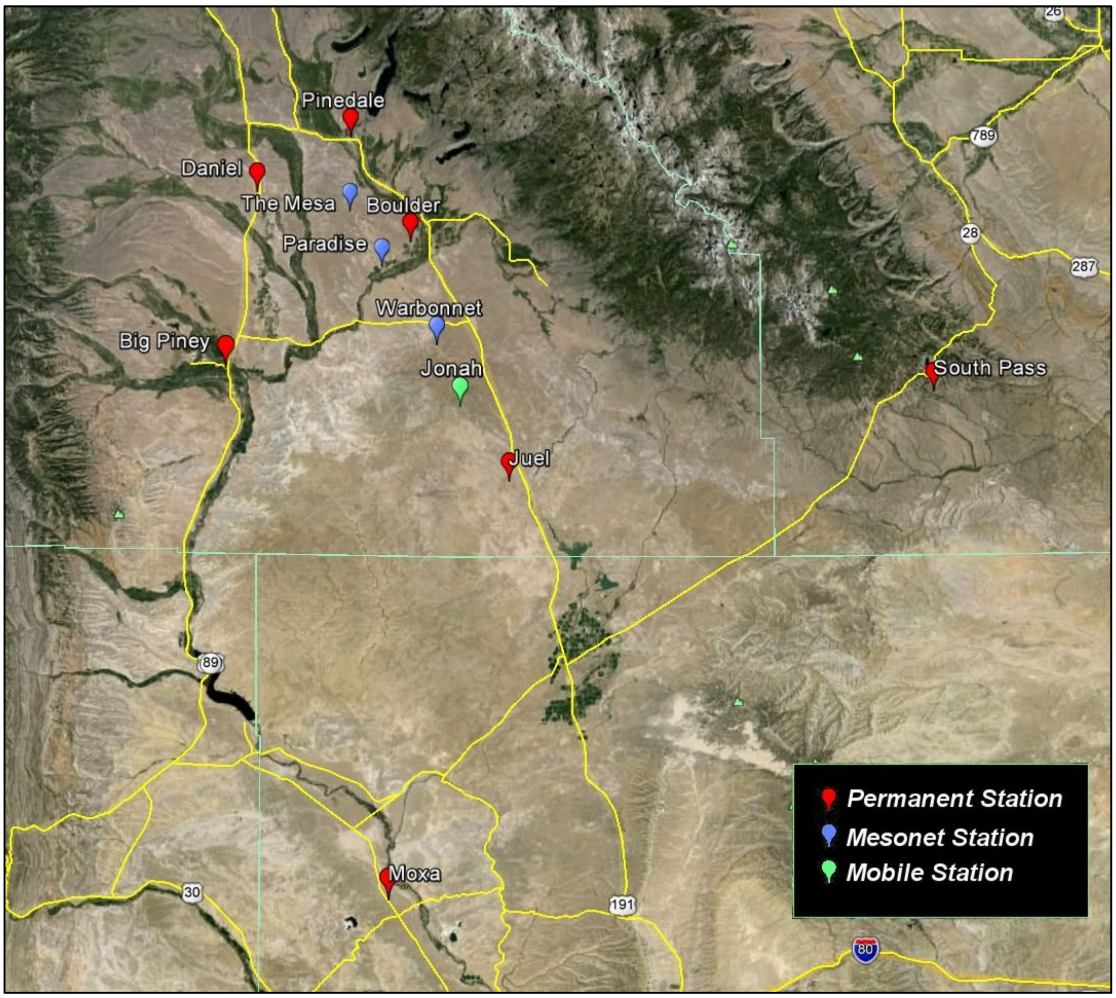

Figure 3.1. Map of UGWOS and Additional Ozone Monitoring Site Locations

Table 3-1. Monitoring Locations

Site	Latitude	Longitude	Elev.
SODAR SITE			
Boulder	42.7188	-109.7529	7078’
MESONET SITES			
Mesa	42.7774	-109.8829	7522’
Paradise	42.6825	-109.8090	6966’
Warbonnet	42.5703	-109.7022	7414’
JONAH AREA SITE			
Jonah (2014)	42.4736	-109.6497	7259’
EXISTING MONITORING SITES OF INTEREST			
Big Piney	42.4870	-110.0995	6823’
Daniel	42.7910	-110.0650	7084’
Farson	42.1184	-109.4541	6619’
Pinedale	42.8698	-109.8707	7186’
Juel Spring	42.3735	-109.5605	7020’
South Pass	42.528	-108.720	8287’
Moxa	41.750	-109.788	6460’

SECTION 4

MONITORING EQUIPMENT DESCRIPTION

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

4.1 MESONET MONITORING SITES

All equipment used at the mesonet ozone monitoring sites will be housed in 70 to 100-quart insulated containers. Two 110 amp-hour deep cycle 12-Volt battery will power all equipment. Each site will be equipped with solar panels, allowing continuous monitoring with an Option Wireless Technology - Globesurfer III™ cellular IP router for remote telecommunications.

The following equipment will be at each of the mesonet sites:

2B Model 202 Ozone Analyzer

The 2B Ozone Monitor will be used for the mesonet monitoring. This monitor has low power consumption (12v DC, 0.33 amp, 4.0 Watt) relative to conventional instruments allowing operation with deep cycle batteries. Additionally, it does not require a temperature-controlled environment. The 2B Technologies Model 202 Ozone Monitor™ is designed to enable accurate and precise measurements of ozone ranging from low ppb (precision of ~1 ppbv) up to 100,000 ppb (0-100 ppm) based on the well-established technique of absorption of light at 254 nm. "Absorption spectroscopy" is a chemical analysis technique made possible by the phenomenon that a given molecule absorbs light at selected wavelengths. The wavelengths absorbed are characteristic of each molecule's atomic features. The amount of light radiation absorbed by a substance depends on two factors: the number of molecules in the path of the light, and the characteristics of the molecule (e.g., absorption cross-section). Measurement of changes in the light intensity as it passes through the molecules, and the use of calibration and reference data, enable the determination of the number of molecules encountered.

Accuracy (performance checks)	±5%
Precision (performance checks)	±5%
Resolution	0.001 ppm
Lower Quantifiable Limit	0.002 ppm

RM Young Model 05305 Wind Monitor AQ

For surface monitoring of wind speed and wind direction at the mesonet sites, we will employ RM Young 05305 Wind Monitor AQ wind speed and direction sensors. These sensors employ a propeller anemometer. The sensors will be mounted on 3-meter tripods (**Figure 4.1**), 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.

Figure 4.1. Tripod Mounting of Wind Sensors.

Monitoring quality objectives for the supplemental surface wind measurements are presented below.

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

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.

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 the Jonah Field and 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.

4.2 JONAH MONITORING SITE

Air quality monitoring at the Jonah site will be conducted using the following equipment:

Thermo Scientific Model 42*i* NO/NO_2/NO_X Analyzer – EPA Approval RFNA-1289-074

The Model 42*i* uses the chemiluminescence detection principle, coupled with state-of-the-art microprocessor technology to provide the sensitivity, stability and ease of use needed for ambient monitoring requirements. The analyzer uses multi-tasking software, which allows complete control of all functions while providing online indication of important operating parameters. Measurements are automatically compensated for temperature and pressure changes.

Accuracy	±5%
Precision	±5%
Resolution	1 ppb
Lower Quantifiable Limit	2 ppb

Thermo Scientific Model 49*i* Ozone Analyzer – EPA Approval EQOA-0880-047

The Model 49*i* Ozone Analyzer is a microprocessor-controlled analyzer that uses a system based on the Beer-Lambert law for measuring low ranges of ozone in ambient air. The Model 49i Ozone Analyzer uses a dual-cell, UV photometric gas analyzer for measurement of ambient air monitoring. Because the instrument has both sample and reference flowing at the same time, a response time of 20 seconds can be achieved. Temperature and pressure corrections are performed automatically.

Accuracy	±5%
Precision	±5%
Resolution	1 ppb
Lower Quantifiable Limit	2 ppb

Teledyne/API Model 700EU Calibrator

The Model 700EU is a microprocessor based calibrator for precision gas analyzers. Using a combination of highly accurate mass flow controllers and compressed sources of standard gases, calibration standards are provided for multipoint span and zero checks. Up to 4 gas sources may be used. In addition, the Model 700EU is equipped with an optional built-in, programmable ozone generator for accurate, dependable ozone calibrations and to produce NO_2 when blended with NO gas in the internal GPT chamber. As many as 50 independent calibration sequences may be programmed into the M700EU, covering time periods of up to one year. These sequences may be actuated manually, automatically, or by a remote signal. Dilution air is supplied to the calibrator using an API Model 701H zero air system.

RM Young Model 05305 Wind Monitor AQ

For monitoring of wind speed and wind direction an RM Young 05305 Wind Monitor AQ wind speed and direction sensor will be employed. These sensors use a propeller-type anemometer. The direction vane will be oriented to true north using either a compass or the GPS walkoff method.

Accuracy (instrument specifications)	
Horizontal Wind Speed	±(0.2 m/s + 5% of observed)
Horizontal Wind Direction	±5 degrees
Precision	
Horizontal Wind Speed	±0.1 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

Campbell Scientific 109 Temperature Sensor

The temperature will be measured using a Campbell Scientific model 109 sensor. The temperature sensor will be mounted in a naturally aspirated radiation shield.

Absolute Accuracy	±0.5°C
Precision	±0.2°C
Resolution	0.1°C

4.3 REMOTE SENSING UPPER AIR METEOROLOGY

An ASC Model 4000 miniSodar will be used to collect the upper air meteorology data, providing vertically and temporally resolved boundary layer winds and boundary layer depth (i.e., mixing height) data. The system also includes a surface-based meteorological system. The Sodar provides continuous (hourly and 10-minute) wind data with a vertical resolution of 5 meters at heights from approximately 20 meters up to approximately 200 meters agl. The exact height coverage at any given time depends on atmospheric conditions. Continuous (hourly or sub-hourly) boundary layer depth can be derived from the Sodar reflectivity data. An example of this is shown in Figure 4.2. The Sodar will be operated under a configuration that produces the highest quality data for the typical atmospheric conditions found in the Upper Green River Basin.

Accuracy (instrument specifications)	
Horizontal Wind Speed	0.5 m/s
Horizontal Wind Direction	±5°
Maximum Altitude	200 meters
Sampling Height Increment	5 meters and greater
Minimum Sampling Height	20 meters
Transmit Frequency	4500 Hz.
Averaging and Reporting Interval	1 to 60 minutes

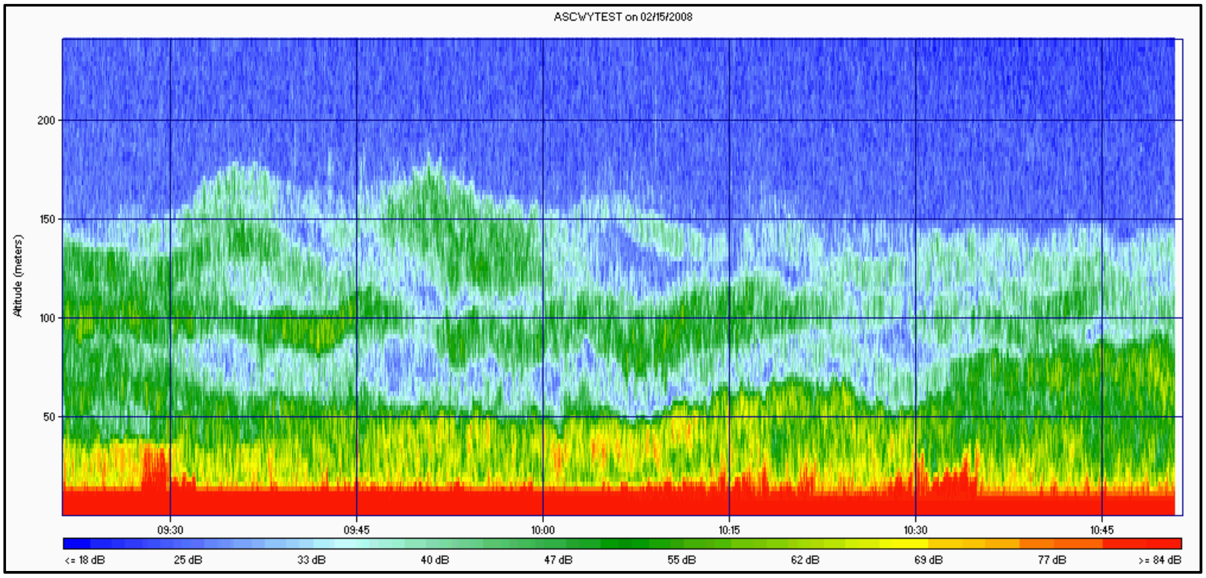

Figure 4.2. Example of Sodar Backscatter Data Capturing the Daytime Mixing Height Layers Under Cold Wintertime Conditions.

4.4 TETHERED SOUNDINGS

Tethersondes will be used to make vertical measurements of ozone, temperature and relative humidity at up to three locations (Boulder, Jonah and Big Piney). The T&B Systems' tethersonde packages will be simple, cost-effective balloon borne instruments and will use the portable ozone saturation sampler developed by T&B Systems. Unlike the MSI tethersonde system, the T&B Systems tethersonde will rely on an onboard datalogger to store data from the measurement platform, which includes ozone (partial pressure) from an EN-SCI Corporation 2ZV7-ECC ozonesonde, ozone cell temperature, ambient temperature and barometric pressure. Barometric pressure and cell temperature will be used to calculate ozone concentration. A secondary onboard data logger will be used to telemeter data to ground level to allow the operator to review data and will also collect and store relative humidity values. Figure 4.2 shows an example of data collected with 5-minute average values at 30-minute intervals, along with the hourly average data from the local ozone monitor. Data were measured and compared at the Santa Clarita, CA SCAQMD monitoring station.

The MSI tethersonde will use the WDEQ iMet-3050 403 MHz GPS Upper-Air Sounding System in a modified configuration to measure and record data using a iMet-1 RSB radiosonde attached to the EN-SCI Corporation 2ZV7-ECC ozonesonde to telemeter data to ground level.

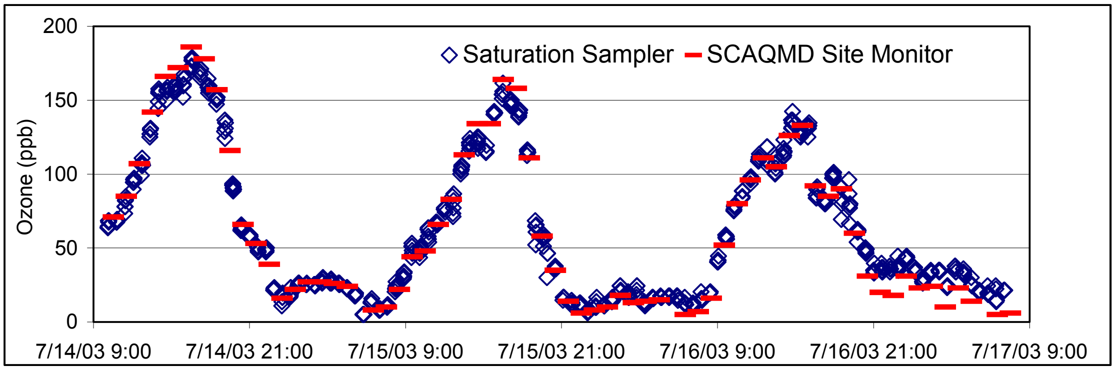

Figure 4.2. Comparison of Saturation Sampler Versus SCAQMD Ozone Data at the Santa Clarita Site in 2003.

The tethersondes with integral ozone measurements operated by T&B Systems and MSI are based on the potassium iodide (KI) bubbler detection principle is described below.

EN-SCI Corporation 2ZV7-ECC Theory of Operation

Ozone is measured with an electrochemical concentration cell (ECC) ozonesonde coupled through an electronic interface to the radiosonde.

The ECC ozonesonde is of a simple design consisting of a rigid mainframe on which is mounted a motor-driven Teflon/glass air sampling pump, a thermistor for measuring pump temperature, an ozone sensing ECC, and an electronics box containing interface circuitry which couple the ozone sensor to the radiosonde. The mainframe is mounted in a lightweight weatherproof polystyrene flight box that is taped and wired to the radiosonde during flight.

The ozone-sensing cell is made of two bright platinum electrodes immersed in potassium iodide (KI) solutions of different concentrations contained in separate cathode and anode chambers. The chambers are linked with an ion bridge that, in addition to providing an ion pathway, retards mixing of the cathode and anode electrolytes thereby preserving their concentrations. The electrolytes also contain potassium bromide (KBr) and a buffer whose concentrations in each half-cell are the same. The driving electromotive force for the cell, of approximately 0.13 V, is provided by the difference in potassium iodide concentrations in the two half cells. Sample air is forced through the ECC sensor by means of a non-reactive pump fabricated from TFE Teflon impregnated with glass fibers. The pump is designed to operate without ozone-destroying lubricants. Pumping efficiency for each pump varies from pump to pump and is also dependent on ambient air pressure. The sampling flow rate is calibrated at the factory and checked in the field before launch. The ECC ozone concentration calibration is also determined prior to launch.

When ozone in air enters the sensor, iodine is formed in the cathode half cell according to the relation:

$$2KI + O_3 + H_2O \rightarrow 2KOH + I_2 + O_2.$$

The cell converts the iodine to iodide according to:

$$I_2 + 2e \rightarrow 2I^-$$

during which time two electrons flow in the cell's external circuit. Measurement of the electron flow (i.e., the cell current), together with the rate at which ozone enters the cell per unit time, enables ozone concentrations in the sampled air to be derived from:

$$p_3 = 4.307 \times 10^{-3}(i_m - i_b)T_p t$$

where p_3 is the ozone partial pressure in nanobars, i_m is the measured sensor output current in microamperes, i_b is the sensor background current (i.e., the residual current emanating from the cell in the absence of ozone in the air) in microamperes, T_p is the pump temperature in Kelvin, and t is the time in seconds taken by the sonde gas sampling pump to force 100 ml of air through the sensor. Below are the ozone sensor specifications and project data accuracy goals.

Sensitivity	2-3 ppb by volume ozone in air
Response Time	15 seconds for 67% of change; 60 seconds for 85% of change
Noise	Less than 1% of full scale
Estimated Measurement Uncertainty	Less than ±10% of indicated value

Accuracy (performance checks)	±10%
Precision (performance checks)	±10%
Resolution	0.001 ppm
Lower Quantifiable Limit	0.002 ppm

4.4 VOC SAMPLING

WDEQ-owned VOC samplers will be retrieved by MSI and bench checked prior to deployment. Figure 4.3 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. Note that these samplers, which were originally used in 2009/2010 for the Pinedale air toxics study, are designed for obtaining both canister and sorbent tube samples.

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'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 brought to the project field office in Pinedale for packaging and shipment 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 Environmental Analytical Services, Inc., San Luis Obispo, CA.

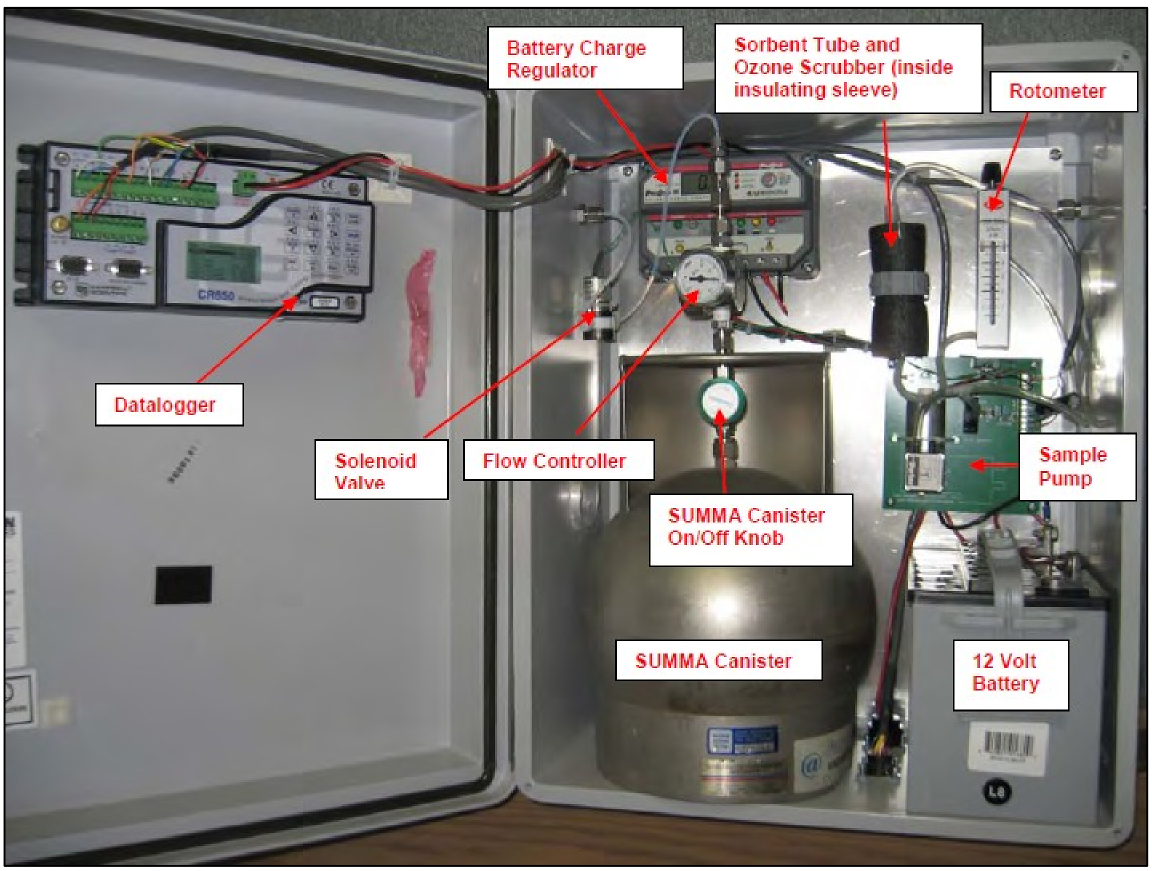

Figure 4.3. Canister Sampler

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

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

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

SECTION 5

DATA REPORTING

5.1 DATA MANAGEMENT PLAN

A primary study objective 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 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 5-minute and hourly averages will be stored in data acquisition systems. 5-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 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 Concentration Map

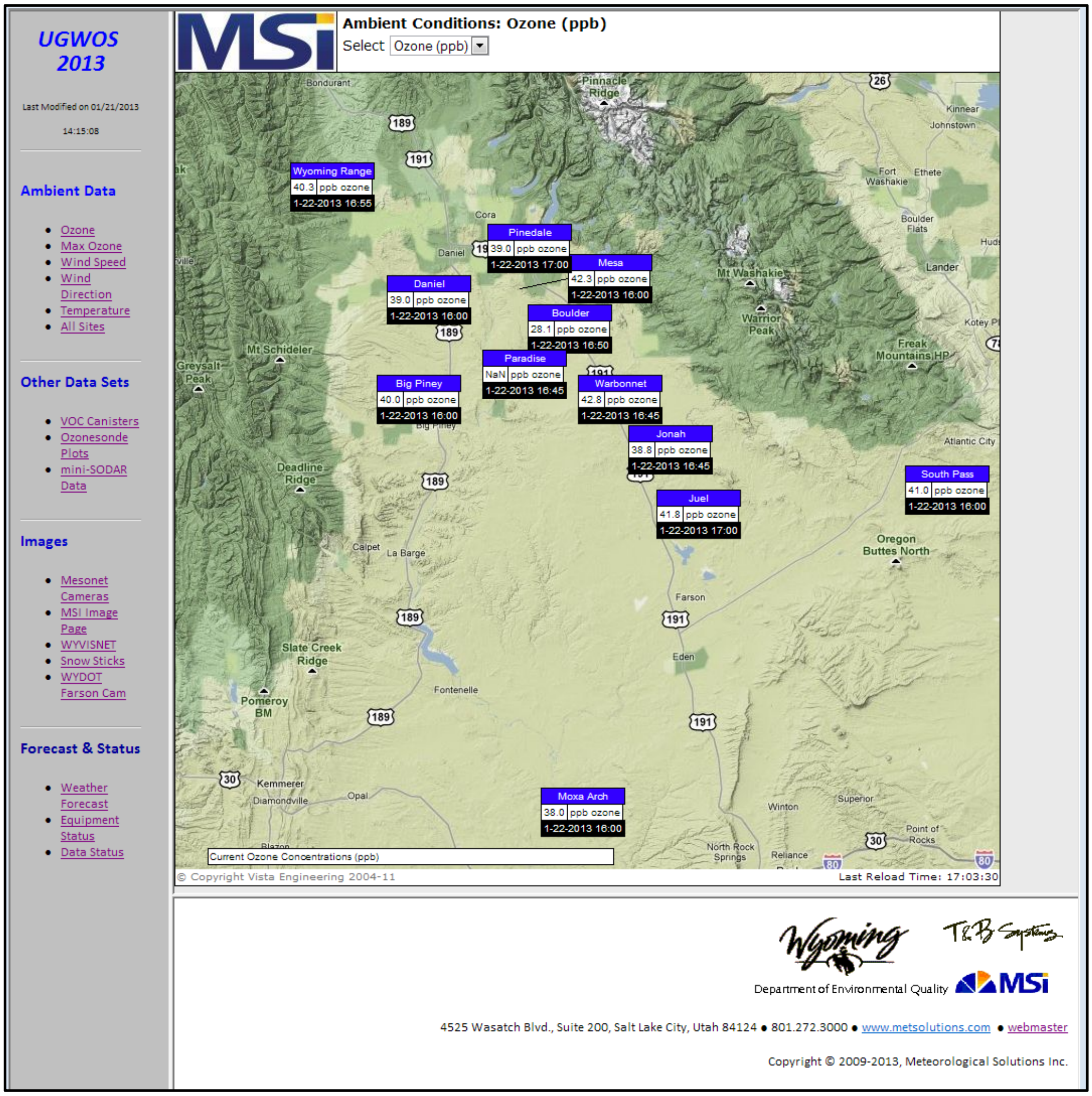

Figure 5.2. Equipment Status

Last Modified on 01/28/2014 10:12:02 UGWOS 2014
Equipment Matrix and Current Status

													Chemiluminescent			Photolytic			Total Reactive Nitrogen		
No.	Site Name	Site Operator	Camera	Canister	Carbonyl	WS	WD	TEMP	RH	THC	O_3	PM	NO	NO_2	NOX	NO	NO_2	NOX	NO	NO_2	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			X										
9	Jonah Trailer Mesonet	MSI	X	X	X	X	X	X			X		X	X	X						
10	Warbonnet Mesonet	MSI	X	X	X	X	X	X			X										
11	Mesa Mesonet	MSI	X	X	X	X	X	X			X										
12	Ozonesonde System	WDEQ/MSI/T&B				X	X	X	X		X										

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

Table 5-1. Data Quality Control Codes

Flag	Description
V	Valid Data
M	Missing Data
I	Invalid Data
S	Suspect Data - Data appears to be a data spike or outside normal data range
U	Data which has not been validated - User is responsible for validation.
N	Instrument Noise detected in sub hourly data used to create hourly average
B	Below Detection Limit
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)

Table 5-1. Data Quality Control Codes

Flag	Description
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
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
B	Below Detection Limit

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.

Database Management Design

MSI 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 - 2013 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:

<u>Surface Hourly Meteorological Data</u>

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

<u>Ozone 8-hour averaged data</u>

SITE, DATE, HOUR, O3_8HR, O38HR_QC

<u>Hourly Surface Air Quality data</u>

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.

<u>Upper level meteorological and air quality data</u>

SODAR data will be stored in both a flat file format and a CDF (common data format) or similar tabular format. CDF files are used for plotting the data. Participants should include both flat files and CDF files with their data submissions. The final flat format will be as follows:

SITE, DATE, HOUR, TIME, HEIGHT, WS, WS_QC, WD, WD_QC

Tethered Sounding Data

Tethersonde data will also be collected during IOPs. The tethersonde database will be developed and refined as the program evolves.

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 by June 1, 2014.

The team will review the validated data collected during the field study and prepare descriptive summaries in a report format for delivery to WDEQ. The Team will prepare summaries of air quality and meteorological conditions during the study period.

In addition, the Team 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, the Team 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. Vertical profiles of winds from the Sodar;
3. Wind roses at the surface;
4. Pollution roses at the surface; and
5. 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 by July 1, 2014. 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

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.

An organizational chart for UGWOS 2014 is provided in Figure 6.1. Study personnel responsibilities and contact information are presented in Table 6-1.

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. Mr. David Yoho 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.

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

QUALITY CONTROL PROCEDURES

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, 2014. 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.

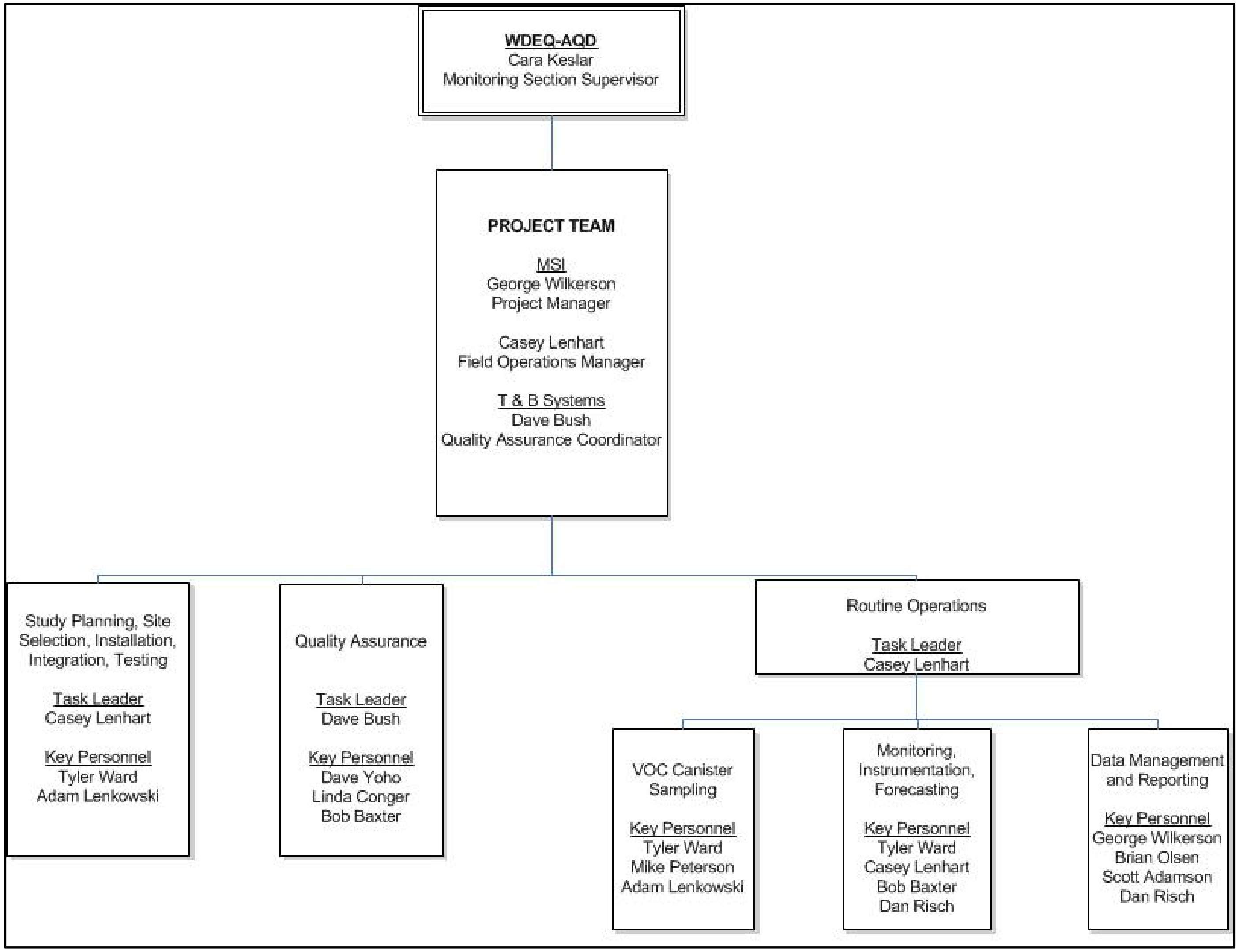

Figure 6.1. Project Organization.

Table 6-2. Project Responsibilities and Contacts

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	Project Manager	(801) 272-3000 Ext. 304
Dan Risch	MSI	Forecasting	(801) 272-3000 Ext. 306
Casey Lenhart	MSI	Field Manager, Reporting	(801) 272-3000 Ext. 307 (801) 979-7874 (cell)
Brian Olsen	MSI	Data polling Data processing and validation, Reporting	(801) 272-3000 Ext. 311
Scott Adamson	MSI	Database and Data Validation, Reporting	(801)-272-3000 Ext. 302
Mike Peterson	MSI	VOC Canister Sampling	(801)-272-3000 Ext. 310 (801)-450-8706 (cell)
Adam Lenkowski	MSI	VOC Canister Sampling	(801)-272-3000 Ext. 309 (801)-419-2882 (cell)
Tyler Ward	MSI	Full-time onsite field technician	(928) 814-3926 (cell)
David Bush	T&B Systems	T&B System's QA Coordinator	(530) 647-1169 (530) 903-6831 (cell)
Bob Baxter	T&B Systems	Sodar operations	(661) 294-1103 (661) 645-0526 (cell)
David Yoho	T&B Systems	Quality Assurance Audits, QAPP, IOP field technician	(661) 294-1103 (661) 212-3008 (cell)

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

Station Checks

Performance of all UGWOS 2014 Jonah monitoring site equipment will be checked daily via remote polling, with site visits occurring at least weekly.

Ozone Transfer Standards

All ozone analyzers and samplers will be routinely checked using a certified transfer standard, following operating procedures consistent with EPA guidelines. For FEM ozone analyzer, these checks will be conducted using a transfer standard certified against a primary standard maintained following EPA's guidelines at MSI's office in Salt Lake City, UT. For the mesonet equipment, a 2B model 306 (S/N 2) portable ozone calibrator will be used. This portable ozone calibrator will also be compared regularly against MSI's primary standard. A pass/fail criterion of +/-10% will be used when evaluating the span and calibration data, after which corrective measures will be implemented.

Mesonet Analyzers

Mesonet 2B ozone analyzers will be checked using certified standards, following operating procedures consistent with EPA guidelines. This will consist of zero, precision, and span checks conducted at least weekly.

Jonah Ozone, NO/NOx Analyzers

Analyzers for the UGWOS 2014 Jonah monitoring effort will be checked using certified standards, following operating procedures consistent with EPA guidelines. This will consist of zero, precision, and span checks conducted automatically every 3 days.

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 2014 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.

MiniSodar

The status of the instruments will be checked daily via remote access of the data. If any problems are encountered that could affect data recovery, repairs will be made promptly. The data will be transferred hourly to T&B's server, using a cellular modem. Data can also be accessed in real time via a web site so that team members can use the data to assist in special monitoring and forecasting. The link to the web site is: http://tbsys.serveftp.net/ugwosSodar/.

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. The calibration method for each of the air quality and meteorological variables is summarized in Table 6-3.

Calibrations of the ozone instruments and the NO/NO_x analyzer will be performed upon initial installation and at the end of the study period. Additional calibrations will be performed on an as-needed basis in the event of equipment repair or replacement. All calibrations will be performed in accordance with manufacturers' recommendations and consistent with USEPA guidance (USEPA, 1994, 1995, 2000).

Calibrations and zero/span checks of all ozone monitoring equipment will be conducted using a transfer standard certified against MSI's primary standard, which is maintained following EPA's guidelines at their office in Salt Lake City, UT, as well as against the US EPA Region 8 primary standard maintained at Golden, CO.

The NO/NO_x analyzer will be calibrated using a certified dilution calibrator and a certified gas standard. Standard gas phase titration (GPT) methodologies will be used for calibration of NO_2 channels.

All meteorological sensors will be calibrated at the beginning and end of the study. Wind speed sensors will be calibrated using an RM 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.

Table 6-3. Calibration Methods for the Monitored Variables.

Measurement Variable	Calibration Method
Ozone (O_3)	Multipoint comparison of ozone concentrations with ozone transfer standard
NO/NO_x	Multipoint comparison of concentrations against a dilution of a certified gas standard
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

INDEPENDENT AUDITS

As part of the quality assurance program, an independent audit program will be implemented that will use an independent entity to verify the site operations and data accuracy. These audits will be performed using personnel independent of the measurement program. This will establish confidence in the data collected and allow the measurement processes to be supported through independent verification. Audits will be performed in accordance with the principles of the US EPA.

System audits will be conducted of all data collection operations, including the Jonah monitoring effort, the MiniSodar setup, the VOC sampling, and the mesonet operations. System audits will address the following:

- Siting
- Adherence to SOPs
- QA/QC procedures
- Documentation
- Data collection and chain of custody

Mr. David Yoho will conduct the systems audits of the UGWOS-specific operations. With the exception of tethersonde operations, Mr. Yoho is independent of all UGWOS 2014 measurements. He will also conduct performance audits of the mesonet sites. Wind speed sensors will be audited using an RM Young constant rpm motor simulating wind speeds at several points across the sensor's operating range. Wind direction sensors will be audited by checking responses in 45° increments. Temperature sensors will be audited using a water bath and a certified audit sensor. The ozone monitors will be audited using an ozone transfer standard that is certified against T&B's Level 2 standard maintained following EPA's guidelines at their office in Valencia, CA.

Performance audits of the measurements at the Jonah site and the WDEQ sites specific to the UGWOS study area will be conducted by Mr. Steve Mugg. Performance audits will be conducted using equipment and standards independent of those used in the field. The ozone analyzers will be audited using an ozone transfer standard that is certified against EPA Region 8's standard reference photometer. The gaseous analyzers will be audited using a certified dilution system and a certified cylinder of EPA protocol blended gas.

All audits will be conducted near the beginning of the study, after the continuous measurements have become operational. Comments and recommendations resulting from the audits will be discussed with measurement personnel at the time of the audit, with a written memo report provided to study management within 48 hours of the audit. Mr. Yoho and Mr. Mugg will work with Mr. Lenhart to verify that any deficiencies noted during the audit are addressed.

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.

SECTION 7

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.

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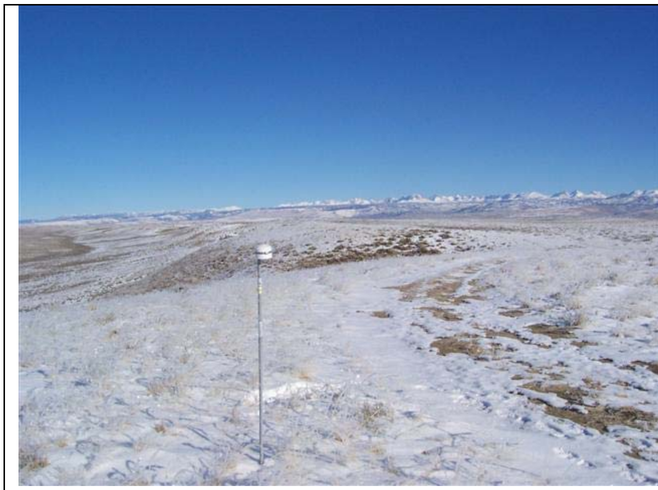
United States Environmental Protection Agency (1999): EPA Requirements for Quality Assurance Project Plans. Document EPA QA/R-5. U.S. EPA Quality Staff Interim Final Report, Research Triangle Park, North Carolina. November.

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 PHOTOS



View to North

View to East

View to South

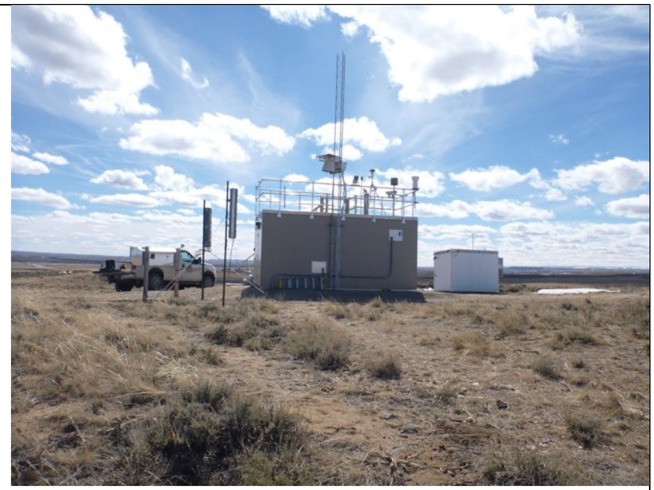
View to West

View of MiniSodar V path (SW)

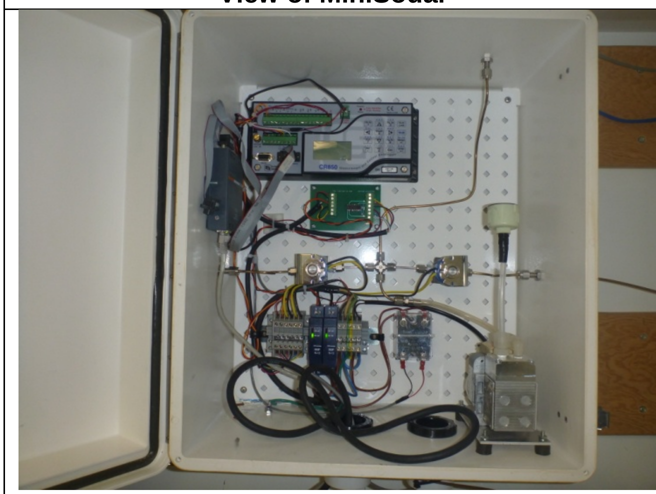
View of MiniSodar U path (NW)

Boulder Site

View of MiniSodar



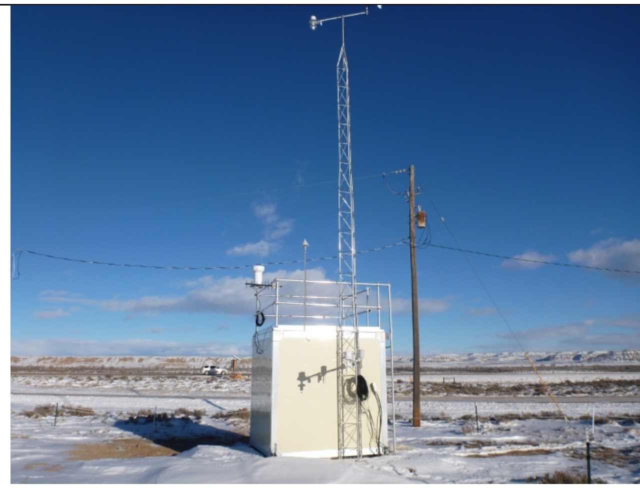
View of Air Quality Site

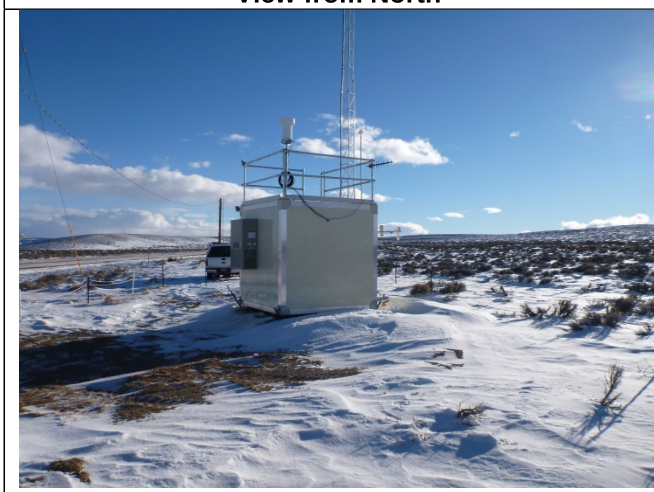


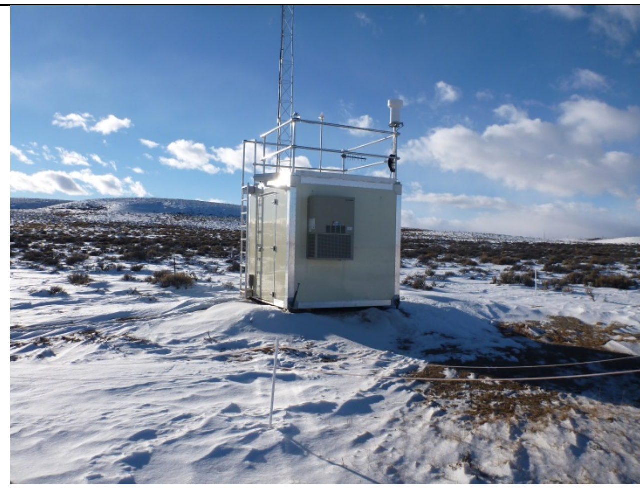
VOC Sampler

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

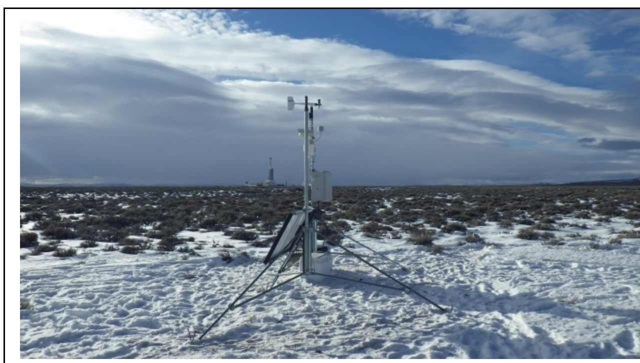
Monitoring Equipment, View from North

View from East

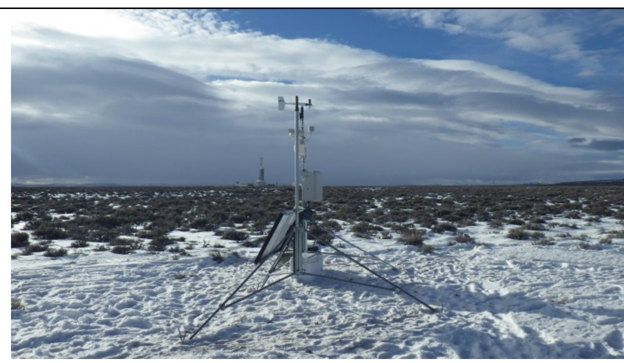
View from South

View from West

Paradise Site



Monitoring Equipment, View from North

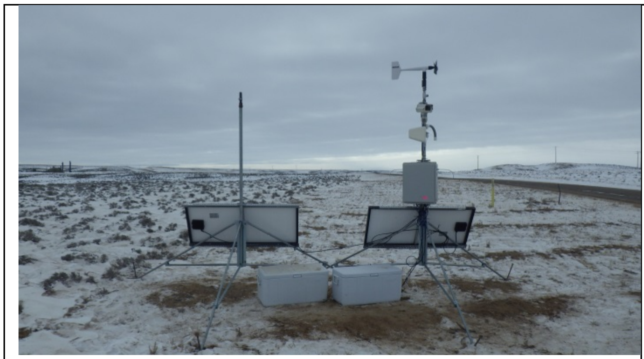


View from East

View from South

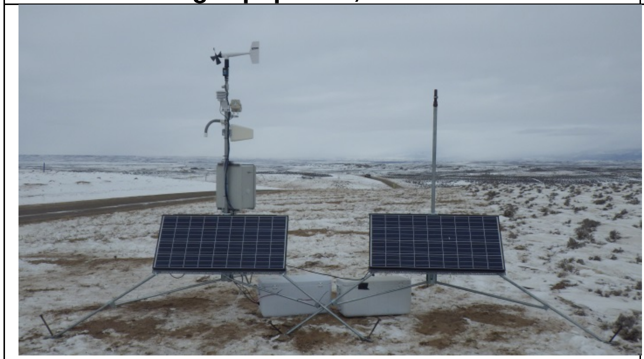
View from West

Mesa Site



Monitoring Equipment, View from North

View from East



View from South

View from West

Warbonnet Site

APPENDIX B

STANDARD OPERATING PROCEDURES