

**Site Location Details, Air Pollution  
Monitoring Equipment Used, Aircraft  
Flight Path Information, and Deployment  
Configuration for the DISCOVER-  
AQ (Deriving Information on Surface  
Conditions from Column and VERTically  
Resolved Observations Relevant to  
Air Quality) Field Campaign in Colorado:  
Summer 2014 - Technical Report**



**Authors: Eric S. Hall (EPA/ORD) and  
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### **Disclaimer**

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# Acronyms/Abbreviations

ACE	Air, Climate and Energy Research Program	NASA	National Aeronautics and Space Administration
API	Advanced Pollution Instrumentation	NC	North Carolina
C <sub>2</sub> H <sub>4</sub>	Ethylene	NCORE	National Core Air Pollution Monitoring Network
CAMP	Continuous Ambient Monitoring Program	NERL	National Exposure Research Laboratory
CDPHE	Colorado Department of Public Health and the Environment	nm	Nanometer
CFR	Code of Federal Regulations	NO	Nitric Oxide
Cl <sub>2</sub>	Chlorine	NO <sub>2</sub>	Nitrogen Dioxide
CO	Carbon Monoxide	NOAA	National Oceanic and Atmospheric Administration
CO	Colorado	NO-CL	Nitric Oxide-Chemiluminescence Method
CO <sub>2</sub>	Carbon Dioxide	NREL	National Renewable Energy Laboratory
DC	Direct Current	NSF	National Science Foundation
DFO	Designated Federal Officer	O <sub>2</sub>	Oxygen
DI	De-ionized	O <sub>3</sub>	Ozone
DISCOVER-AQ	Deriving Information on Surface conditions from Column and Vertically Resolved Observations Relevant to Air Quality	OD	Outer Diameter
DOAS	Differential Optical Absorption Spectroscopy	ORD	Office of Research and Development
EPA	U.S. Environmental Protection Agency	Pb	Lead
ESD	Environmental Sciences Division	PFA	Perfluoroalkoxy alkane
FEM	Federal Equivalent Method	PM	Particulate Matter
FR	Federal Register	PMT	Photomultiplier Tube
FRM	Federal Reference Method	<i>ppm</i>	Parts Per Million
H <sub>2</sub> O	Water	ppb	Part Per Billion
H <sub>2</sub> S	Hydrogen Sulfide	R <sup>2</sup>	Coefficient of Determination
HEASD	Human Exposure and Atmospheric Sciences Division	RH	Relative Humidity
Hg	Mercury	RMS	Root Mean Square
Hv	Photon	RTD	Resistive Temperature Device
IE	Interference Equivalent	RTP	Research Triangle Park
LaRC	NASA Langley Research Center	SIP	State Implementation Plan
LCD	Liquid Crystal Display	SLAMS	State and Local Air Monitoring Station(s)
LDL	Lower Detectible Limit	SO <sub>2</sub>	Sulfur Dioxide
MD	Maryland	TX	Texas
MDE	Maryland Department of the Environment	TCEQ	Texas Commission on Environmental Quality
m	Meter	URL	Upper Range Limit
MDA8	Maximum Daily Eight-Hour Average	U.S. EPA	United States Environmental Protection Agency
MDE	Maryland Department of the Environment	UV	Ultraviolet
MFC	Mass Flow Controller	UV-SL	Scrubberless Ultraviolet Photometric Method
MnO <sub>2</sub>	Manganese Dioxide	V	Volts
NAAQS	National Ambient Air Quality Standard	VOC	Volatile Organic Compounds
		ZAG	Zero Air Generator



# 1.0

## Introduction

EPA scientists from the Office of Research and Development (ORD) National Exposure Research Laboratory (NERL) have collaborated with NASA on a multiyear study aimed at improving the monitoring capability of air pollution measuring satellites in interpreting air quality conditions near the earth's surface. The NASA-led mission — known as “DISCOVER-AQ” — stands for Deriving Information on Surface conditions from COlumn and VERTically resolved observations relevant to Air Quality. The study resulted in an extensive database of satellite, aircraft, and ground-based measurements for gaseous air pollutants and particulate matter over urban areas with persistent air quality problems. Studies were conducted in Baltimore, MD (2011), San Joaquin Valley, CA (2013), Houston TX (2013), and Denver, CO (2014).

The final DISCOVER-AQ field mission occurred in July and August 2014 in the Denver, CO region. The Denver field study was led by Russell Long, Jim Szykman, and Rachelle Duvall. The NASA-NERL collaboration was accomplished under U.S. EPA/ORDs Air, Climate and Energy (ACE) Research Program themes, “Emissions and Measurements for Informing Policy Decisions”, and “Changing the Paradigm for Air Pollution Monitoring”, as one of the five ACE signature research projects. EPA scientists used this DISCOVER-AQ field research activity, along with the three previous ones, as a venue to analyze the performance of FRMs and FEMs for both ozone and NO<sub>2</sub> outside of laboratory and RTP test site conditions. DISCOVER-AQ provided an unprecedented opportunity to collect data on these new methods in four different ambient settings, while also comparing them to data collected from small sensors for these pollutants.

As part of the DISCOVER-AQ project, NASA aircraft made a series of flights with scientific instruments on board to measure gaseous and particulate pollution in the targeted metropolitan areas. These aircraft measurements were taken in concert with satellite and ground measurements to shed light on how satellites can be used to understand pollutant concentrations and distributions near the earth's surface. This flight research activity will provide a greater understanding of how the existing air-monitoring network funded by EPA and run by states and local agencies can be used to improve satellite observations. With improved ability to monitor pollution from satellites, scientists can make better air quality forecasts, more accurately determine sources of pollutants in the air, and more closely determine fluctuations in emissions levels. For more information on the DISCOVER-AQ mission, consult the following resource: DISCOVER-AQ: <http://discover-aq.larc.nasa.gov>.

NERL scientists will continue its collaboration with NASA using data collected from DISCOVER-AQ to help plan for their participation in a newly selected NASA satellite mission called TEMPO, or Tropospheric Emissions: Monitoring of Pollution, which is expected to launch no earlier than 2018. This project involves building the first space-based instrument to monitor major air pollutants across the North American continent hourly during daytime. The instrument, to be completed in 2017, will share a ride on a commercial satellite as a hosted payload to an orbit about 22,000 miles above Earth's equator. Current methods utilize satellites orbiting much closer to the earth's surface, allowing for observations of atmospheric pollutants to be made only once a day.



## 2.0

# Summary of the DISCOVER-AQ (Denver CO – 2014) Colorado Field Mission

For EPA, this DISCOVER-AQ field research activity focused on assessing FRMs and FEMs for ozone (O<sub>3</sub>) and NO<sub>2</sub>, while comparing their operational performance to each other and to small sensors to determine how the measurement characteristics and capabilities of small sensors compare to regulatory monitoring methods. During DISCOVER-AQ, EPA provided key ground-based (in-situ and remote sensing) measurements at sites along the flight path of the project aircraft. The results of the ambient evaluations of current and potential regulatory methods for O<sub>3</sub> and NO<sub>2</sub> will inform current and future NAAQS reviews with respect to methods used for NAAQS compliance monitoring. The evaluation of small sensors for O<sub>3</sub> and NO<sub>2</sub>, along with the associated ‘citizen science’ monitoring, were leveraged during the Denver DISCOVER-AQ field study. The information and data in this EPA Technical Report documents the monitoring equipment, monitoring configuration, monitoring site locations, site and equipment points-of-contact, aircraft flight path and flight plan information, etc., for the DISCOVER-AQ Denver CO (2014) field monitoring activity. This report was developed to preserve and document the key information and details associated with the 2014 DISCOVER-AQ field campaign in Denver CO. This report includes the following details:

- a.) Information on small sensor sites
- b.) Ground site equipment by measurement type/category
- c.) Ground site monitoring equipment details
- d.) Monitoring aircraft flight paths
- e.) Monitoring aircraft flight plans
- f.) Monitoring aircraft photographs
- g.) Ground site location information (site owner, longitude, latitude, altitude [ft and m])
- h.) Site-to-site distance between monitoring locations (south-to-north: by latitude)
- i.) Points-of-contact for monitoring organizations (with contact information)
- j.) Points-of-contact for monitoring equipment manufacturers (with contact information)
- k.) Ground site information (site owner, address, site contact, notes, photos)

The goal of this EPA Technical Report is to *provide the details of the 2014 DISCOVER-AQ field campaign in a single reference document to facilitate the generation of peer-reviewed, scientific journal article manuscripts* that will be written about this field activity. This ensures that the important site and equipment configuration details are preserved for this research project and that journal articles written on this research effort use the same, consistent information, derived from a single baseline source.

There were 28 ground monitoring site locations used in the DISCOVER-AQ Denver field intensive. These sites were visited during the week of 28 July 2014 – 01 Aug 2014 (Monday through Friday). The pattern for site visits was to visit sites in geographic ‘clusters’ (sites located in close proximity to each other) to minimize travel time between sites and to reach the maximum number of sites possible in the shortest amount of time. ***The information about each site, including the instruments and the type of measurements made at all 28 ground-based sites, is provided in this report.***

Given the project size, geographical scope, number and diversity of ground-based and aircraft-based monitoring equipment types, number and locations of monitoring sites, number of different research teams and organizations, the logistics of site setup, data collection, coordination of the activities of multiple research teams, transportation requirements, etc., recommendations are provided in this report as a guide for planning and executing future field campaigns similar to the 2014 DISCOVER-AQ field campaign (Denver CO).



### 3.0

## Recommendations for Future Large-Scope Monitoring Field Intensives:

The planning, configuration, setup, and implementation of a large intensive air pollution measurement field study with more than two dozen sites located in multiple counties having different topological, hydrological, and geographical environments is a complex undertaking. Determining where to site instruments, making provisions for change out and storage of filters, ensuring that there are spare parts, tools, and the details of data collection and dismantling of the applicable sites at the end of the study is the primary focus of the research team. During the term of the field study, a number of research personnel, audit personnel, and other personnel for various reasons will require access to one or more of the sites. It is important that key information for each site be maintained in a single document so that as site personnel travel to and between the different study locations, they can navigate from site to site and have contact information on each site for access and in case of emergencies. Specific recommendations for large, multi-site field studies, such as the DISCOVER-AQ Denver field intensive, is provided below:

1. Ensure that correct street/highway/road/address designations are provided for all site locations (including remote/rural/mountain-based sites) by state partners (e.g., **Parkway** [incorrect designation] vice **Highway** [correct designation]; **West Highway 123** or **East Highway 123** [incorrect designation] vice **State Highway 123** [correct designation])
2. Provide physical landmarks/guideposts as direction/distance/location markers for sites located in remote/rural/mountain-based sites that are not located in urban areas or on numbered streets
3. Ensure that the correct city/town/county designation is used for each site, regardless of location (e.g., **Aurora** Colorado [incorrect designation] vice **Watkins** Colorado [correct designation]; **Jackson Reservoir** [incorrect designation] vice **Jackson Lake State Park** [correct designation] – **Note: Jackson Reservoir** is located inside of **Jackson Lake State Park**)
4. Ensure that a point of contact and telephone number is provided for each individual site, including remote/rural/mountain-based sites
5. Ensure that when streets/highways/roads change names, this information is provided to aid in location of sites
6. Ensure that when latitude and longitude coordinates are provided for sites that they are provided in both decimal degree format and degrees, minutes and seconds format to facilitate use of both Google Earth and MapQuest for location of remote/rural/mountain-based sites
7. Ensure that for remote/rural/mountain-based areas, accurate and complete directions are provided to facilitate location of site and site equipment (especially for sites located in state and US national parks and grasslands, which may consist of hundreds of acres/hectares)
8. Ensure that location to nearest hospital/medical facility is provided for each individual site, including remote/rural/mountain-based sites
9. Ensure that topographical map and hiking map/trail information is provided for each mountain-based site location, especially for sites located in state parks or US National Forests and National Grasslands (e.g., Arapaho National Forest/Arapaho-Roosevelt National Forests and Pawnee National Grasslands [ARP])
10. Ensure that for remote/rural/mountain-based sites located in state parks or US National Forests and National Grasslands, the phone number and duty location for the nearest state or US forest ranger is provided
11. Ensure for sites located in urbanized areas (e.g., downtown and/or office building complex [i.e., CAMP]) which may be indistinguishable from the surrounding landscape/area, that specific directions are provided to the exact building location





## 4.0

### References:

DISCOVER-AQ Colorado Site Survey Report  
(16-19 December 2013)



# APPENDIX A

**Table 1. Small Sensor Sites**

Site	Equipment	Manufacturer	Parameter (s) Measured	Power Requirements	Dimensions	Number of Units	Comments
NREL-Golden	AQMesh	AQMesh Corp	NO <sub>2</sub> , NO, O <sub>3</sub> , CO, SO <sub>2</sub>	Lithium ion battery	4.6 x 7.0 x 5.5 in	4	
	O <sub>3</sub> /NO <sub>2</sub> CairClip	CairPol	O <sub>3</sub> , NO <sub>2</sub>	Solar powered	32 x 62 mm	1	
	NO <sub>2</sub> CairClip	CairPol	NO <sub>2</sub>	Solar powered	32 x 62 mm	1	
	Elm	Perkin Elmer	NO <sub>2</sub> , NO, O	12V Adapter	26 x 17 x 7 cm	3	
	Aeroqual O <sub>3</sub>	Aeroqual	O <sub>3</sub>	12V Adapter	195 x 122 x 54 mm	3	
	Aeroqual NO <sub>2</sub> /RH/T	Aeroqual	NO <sub>2</sub> , RH, T	12V Adapter	195 x 122 x 54 mm	1	
BAO Tower	O <sub>3</sub> /NO <sub>2</sub> CairClip	CairPol	O <sub>3</sub> , NO <sub>2</sub>	Solar powered	32 x 62 mm	4	at GL, 100m, 200m, 300m
	NO <sub>2</sub> CairClip	CairPol	NO <sub>2</sub>	Solar powered	32 x 62 mm	4	at GL, 100m, 200m, 300m
	Aeroqual O <sub>3</sub>	Aeroqual	O <sub>3</sub>	12V Adapter	195 x 122 x 54 mm	1	at GL
Denver-LaCasa	AQMesh	AQMesh Corp	NO <sub>2</sub> , NO, O <sub>3</sub> , CO, SO <sub>2</sub>	Lithium ion battery	4.6 x 7.0 x 5.5 in	4	at GL, 100m, 200m, 300m
	AqMesh	AQMesh Corp	NO <sub>2</sub> , NO, O <sub>3</sub> , CO, SO <sub>2</sub>	Lithium ion battery	4.6 x 7.0 x 5.5 in	2	
	Aeroqual O <sub>3</sub>	Aeroqual	O <sub>3</sub>	12V Adapter	195 x 122 x 54 mm	1	
	Aeroqual NO <sub>2</sub> /RH/T	Aeroqual	NO <sub>2</sub> , RH, T	12V Adapter	195 x 122 x 54 mm	1	
Denver-I-25	AQMesh	AQMesh Corp	NO <sub>2</sub> , NO, O <sub>3</sub> , CO, SO <sub>2</sub>	Lithium ion battery	4.6 x 7.0 x 5.5 in	1	
	O <sub>3</sub> /NO <sub>2</sub> CairClip	CairPol	O <sub>3</sub> , NO <sub>2</sub>	Solar powered	32 x 62 mm		
	NO <sub>2</sub> CairClip	CairPol	NO <sub>2</sub>	Solar powered	32 x 62 mm	1	
Colorado School of Mines	AQMesh	AQMesh Corp	NO <sub>2</sub> , NO, O <sub>3</sub> , CO, SO <sub>2</sub>	Lithium ion battery	4.6 x 7.0 x 5.5 in	1	Located on library rooftop
	O <sub>3</sub> /NO <sub>2</sub> CairClip	CairPol	O <sub>3</sub> , NO <sub>2</sub>	Solar powered	32 x 62 mm	1	Located on library rooftop
	NO <sub>2</sub> CairClip	CairPol	NO <sub>2</sub>	Solar powered	32 x 62 mm	1	Located on library rooftop
Golden Residence	AQMesh	AQMesh Corp	NO <sub>2</sub> , NO, O <sub>3</sub> , CO, SO <sub>2</sub>	Lithium ion battery	4.6 x 7.0 x 5.5 in	1	
	O <sub>3</sub> /NO <sub>2</sub> CairClip	CairPol	O <sub>3</sub> , NO <sub>2</sub>	Solar powered	32 x 62 mm	1	
EPA Region 8	AQMesh	AQMesh Corp	NO <sub>2</sub> , NO, O <sub>3</sub> , CO, SO <sub>2</sub>	Lithium ion battery	4.6 x 7.0 x 5.5 in	1	Located on rooftop
	O <sub>3</sub> /NO <sub>2</sub> CairClip	CairPol	O <sub>3</sub> , NO <sub>2</sub>	Solar powered	32 x 62 mm	1	Located on rooftop
	NO <sub>2</sub> CairClip	CairPol	NO <sub>2</sub>	Solar powered	32 x 62 mm	1	Located on rooftop

**Table 2. Ground Sites By Measurement Type/Category**

Name	Latitude	Longitude	Alt (ft)	Description	Spiral	Overflight	Pandora	Aeronet	EPA NO <sub>2</sub>	Missed Approach	O <sub>3</sub>	NO <sub>2</sub>
BAO Tower	40.050030	-105.003835	5186	NOAA site	X		2	X			CSU	CSU
Chatfield Park	39.534500	-105.070365	5498	CDPHE, 08-035-0004	X		1	X	Photolytic		CDPHE	EPA
Denver-LaCasa Ncore	39.779490	-105.005180	5254	CDPHE, 08-031-0026	X		1	X	CAPS		CDPHE	EPA
Fort Collins-West	40.592795	-105.141410	5156	CDPHE, 08-069-0011	X		1	X	Photolytic	500 feet	CDPHE	EPA
NREL-Golden	39.743725	-105.177990	6015	CDPHE, 08-059-0011	X		2	X	FRM/CRDS		CDPHE	EPA
Platteville	40.182765	-104.726100	4997	NOAA site	X		1	X	CAPS		NOAA/NATIVE	EPA/NATIVE
Aurora East/DU-ARTI	39.638540	-104.569130	5912	CDPHE, 08-005-0006				X			CDPHE	
Boulder	39.991859	-105.261325	5447	NOAA site		X	1	X				
CAMP	39.751190	-104.987610	5226	CDPHE, 08-031-0002		X					CDPHE	CDPHE
I-25 Denver	39.732146	-105.015317	5207	971 Yuma St.			1		CAPS			CDPHE/EPA
Niwot Ridge	40.031795	-105.533313	9467	NOAA site			1	X				
Rocky Flats - N	39.912795	-105.188575	5915	CDPHE, 08-059-0006		X	1	X			CDPHE	
Squaw Mtn	39.679690	-105.493284	11456				1	X			CDPHE-temp	
Table Mountain	40.124741	-105.236979	5535	NOAA site		X	1	X			CDPHE-temp	
Welch	39.638780	-105.139510	5719	CDPHE, 08-059-0005		X					CDPHE	
Weld Co. Tower	40.386360	-104.737445	4869	CDPHE, 08-123-0009		X	1	X			CDPHE	
Greeley-Weld Co. Airport	40.441377	-104.631188	4672							X		
Parkland Airport	40.070854	-105.027530	5053							500 feet		
Centennial Cone	39.760299	-105.360728	7850									
Daniels Park	39.4822	-104.9306	6491								CDPHE-temp	
Fort Collins-CSU	40.577470	-105.078920	5002	CDPHE, 08-069-1004							CDPHE	
Fritz Peak	39.908062	-105.491687	8797									
Golden Gate Fire Dept	39.776725	-105.36815	8045								CDPHE-temp	
Jackson Reservoir SP	40.38815	-104.09461	4467								CDPHE-temp	
Colorado Mines Peak	39.794099	-105.764158	12458								CDPHE-temp	
North Fork Fire Dept	39.3616	-105.24493	7620								CDPHE-temp	
South Boulder Creek	39.957205	-105.238460	5483	CDPHE, 08-013-0011							CDPHE	
Welby	39.838200	-104.949845	5105	CDPHE, 08-001-3001							CDPHE	

**Table 2. Ground Sites By Measurement Type/Category (continued)**

Name	NO <sub>x</sub> /NO <sub>y</sub>	WS/WD/T	SO <sub>2</sub>	CO	CO <sub>2</sub> , CH <sub>4</sub>	NMHCs	PM <sub>2.5</sub>	PM <sub>10</sub>	Lidars	Balloons	Comment
BAO Tower									NOAA-TOPAZ and HRDL, UW-HSRL, H <sub>2</sub> O DIAL		CSU, 3 mobile hookups, small sensors on tower; aeronet already in place
Chatfield Park		CDPHE									
Denver-LaCasa Ncore	CDPHE		CDPHE				CDPHE	CDPHE			
Fort Collins-West									GSFC TOLNET-O <sub>3</sub> , MPL	Limited Ozonesondes	
NREL-Golden	Millersville								MPL, LaRC TOLNet-O <sub>3</sub> , and Leosphere	Tethersonde radiosondes	Millersville also brings sodar, flux tower, nephelometer; Pandoras by EPA here, EPA ceilometer, UMBC trailer, NOAA profiler
Platteville	NATIVE	NATIVE	NATIVE	NATIVE	NATIVE	Wisthaler				Ozonesondes	NATIVE; NOAA radiation; 3 mobile hookups; Pandora by NATIVE here; extra trailer for PTR-MS
Aurora East/DU-ARTI		CDPHE									Nothing extra planned for this site
Boulder											Pandora already at this location
CAMP	CDPHE	CDPHE	CDPHE	CDPHE			CDPHE	CDPHE			
I-25 Denver											near-road NO <sub>2</sub> monitor; small sensors
Niwot Ridge											
Rocky Flats - N		CDPHE									
Squaw Mtn											
Table Mountain											
Welch		CDPHE									
Weld Co. Tower		CDPHE									remote sensors on county building
Greeley-Weld Co. Airport											Missed approach along BL run
Parkland Airport											Missed approach with BAO spiral
Centennial Cone											
Daniels Park											
Fort Collins-CSU		CDPHE		CDPHE							Nothing extra planned for this site
Fritz Peak											
Golden Gate Fire Dept											
Jackson Reservoir SP											
Colorado Mines Peak											
North Fork Fire Dept											
South Boulder Creek											Nothing extra planned for this site
Welby	CDPHE	CDPHE	CDPHE					CDPHE			Nothing extra planned for this site

**Table 3a. EPA Monitoring Equipment (Details)**

Site	Equipment	Power Req	Dimensions	Info.	Gas Cylinder
NREL-Golden	NO <sub>2</sub> FRM	100V-120V, 220V-240V, 50/60 Hz	rack		1) Trigas
(ORD Trailer)	CRDS NO <sub>2</sub>		bench		2) NO 1% (T265)
	T500U (ORD)	80W; 100-250VAC (50-60Hz)	rack		3) Ethylene (Bendix)
	UVF SO <sub>2</sub>	100-115 VAC	rack		4) N <sub>2</sub> O 95% (2B 211)
	48i CO	100-115 VAC	rack		5) NO <sub>2</sub> 10 PPM
	2B 211 O <sub>3</sub> (X <sub>2</sub> )		rack	Scrubberless UV O <sub>3</sub>	
	T265 O <sub>3</sub>	100V-120V, 220V-240V, 50/60 Hz	rack		
	Bendix 8002 FRM O <sub>3</sub>		rack		
	TSI APS		bench	particle size and count	
	T700U Calibrator	85V-264V, 47Hz-63Hz	rack		
	701H ZAG	115V, 60 Hz	rack or floor		
	Celiometer	110V	outside		
	Pandoras (2)		outside		
	Ecotech NO <sub>y</sub>		rack	External Moly NO <sub>y</sub>	
	Envivas Ultimate				
Chattfield park	200eup NO <sub>2</sub> (Long)	100V-120V, 220V-240V, 50/60 Hz	rack	Photolytic NO <sub>2</sub>	1) 20 ppm NO
	T700U Calibrator	85V-264V, 47Hz-63Hz	rack		
	701H ZAG	115V, 60 Hz	rack or floor		
Denver La Casa	T500U (OAQPS)	80W; 100-250VAC (50-60Hz)		CAPS NO <sub>2</sub>	NA
Denver I-25	T500U (T-API)	80W; 100-250VAC (50-60Hz)		CAPS NO <sub>2</sub>	NA
Platteville	Env. SA CAPS			CAPS NO <sub>2</sub>	NA
(Penn State)					
Fort Collins West	200eup NO <sub>2</sub> (Szykman)	100V-120V, 220V-240V, 50/60 Hz	rack	Photolytic NO <sub>2</sub>	1) 20 PPM NO
	2B 211 O <sub>3</sub>		rack	Scrubberless UV O <sub>3</sub>	2) N <sub>2</sub> O (2B 211)
	T700U Calibrator (Szykman)	85V-264V, 47Hz-63Hz	rack		
	701H ZAG (Szykman)	115V, 60 Hz	floor		
	Envivas Ultimate (Szykman)				
Mobile Cal	T-API Calibrator (Alion)	85V-264V, 47Hz-63Hz			1) Trigas
	T-API ZAG (Alion)	115V, 60 Hz			2) NO <sub>2</sub> 10 PPM

**Table 3b. EPA Monitoring Equipment (Details)**

Site	Parameter Measured	Manufacturer and Model	Operation Principle	FRM/FEM Status	Equipment Type	Number of Units	Power Requirements	Dimensions
NREL-Golden	NO <sub>2</sub>	Teledyne API Model T200U	Thermal converter-chemiluminescence	FRM	NO <sub>2</sub> FRM	1	100V-120V, 220V-240V, 50/60 Hz	rack
	NO <sub>2</sub>	Los Gatos Research CRDS	CRDS	N/A	CRDS NO <sub>2</sub>	1		bench
	NO <sub>2</sub>	Teledyne API Model T500U	CAPS	FEM	T500U	1	80W; 100-250VAC (50-60Hz)	rack
	SO <sub>2</sub>	Thermo Scientific Model 43i	Pulsed UV Fluorescence	FEM	UVF SO <sub>2</sub>	1	100-115 VAC	rack
	CO	Thermo Scientific Model 48i	Nondispersive Infrared	FRM	48i CO	1	100-115 VAC	rack
	O <sub>3</sub>	2B Technologies Model 211	Scrubberless UV Photometric	FEM	2B 211 O <sub>3</sub>	2		rack
	O <sub>3</sub>	Teledyne API Model T265	NO-Chemiluminescence	FEM	T265 O <sub>3</sub>	1	100V-120V, 220V-240V, 50/60 Hz	rack
	O <sub>3</sub>	Bendix Model 8002	Ethylene-Chemiluminescence	FRM	Bendix 8002 FRM O <sub>3</sub>	1		rack
	Particle size and count	TSI APS Model ?			TSI APS	1		bench
	Mixing layer heights	Vaisala CL-51 Celiometer		N/A	Celiometer	1	110V	outside
		PANDORA		N/A	Pandora	2		outside
	Noy	Ecotech Noy			Ecotech NO <sub>y</sub>	1		rack
Chattfield park	NO <sub>2</sub>	Teledyne API Model 200EUP	Photolytic Convert-Chemiluminescence	FEM	200eup NO <sub>2</sub> (Long)	1	100V-120V, 220V-240V, 50/60 Hz	rack
Denver La Casa	NO <sub>2</sub>	Teledyne API Model T500U	CAPS	FEM	T500U (OAQPS)	1	80W; 100-250VAC (50-60Hz)	
Denver I-25	NO <sub>2</sub>	Teledyne API Model T500U	CAPS	FEM	T500U (T-API)	1	80W; 100-250VAC (50-60Hz)	
Platteville	NO <sub>2</sub>	Environment SA CAPS	CAPS	FEM	Env. SA CAPS	1		
Fort Collins West	NO <sub>2</sub>	Teledyne API Model 200EUP	Photolytic Convert-Chemiluminescence	FEM	200eup NO <sub>2</sub>	1	100V-120V, 220V-240V, 50/60 Hz	rack
	O <sub>3</sub>	2B Technologies Model 211	Scrubberless UV Photometric		2B 211 O <sub>3</sub>	1		rack





## APPENDIX B

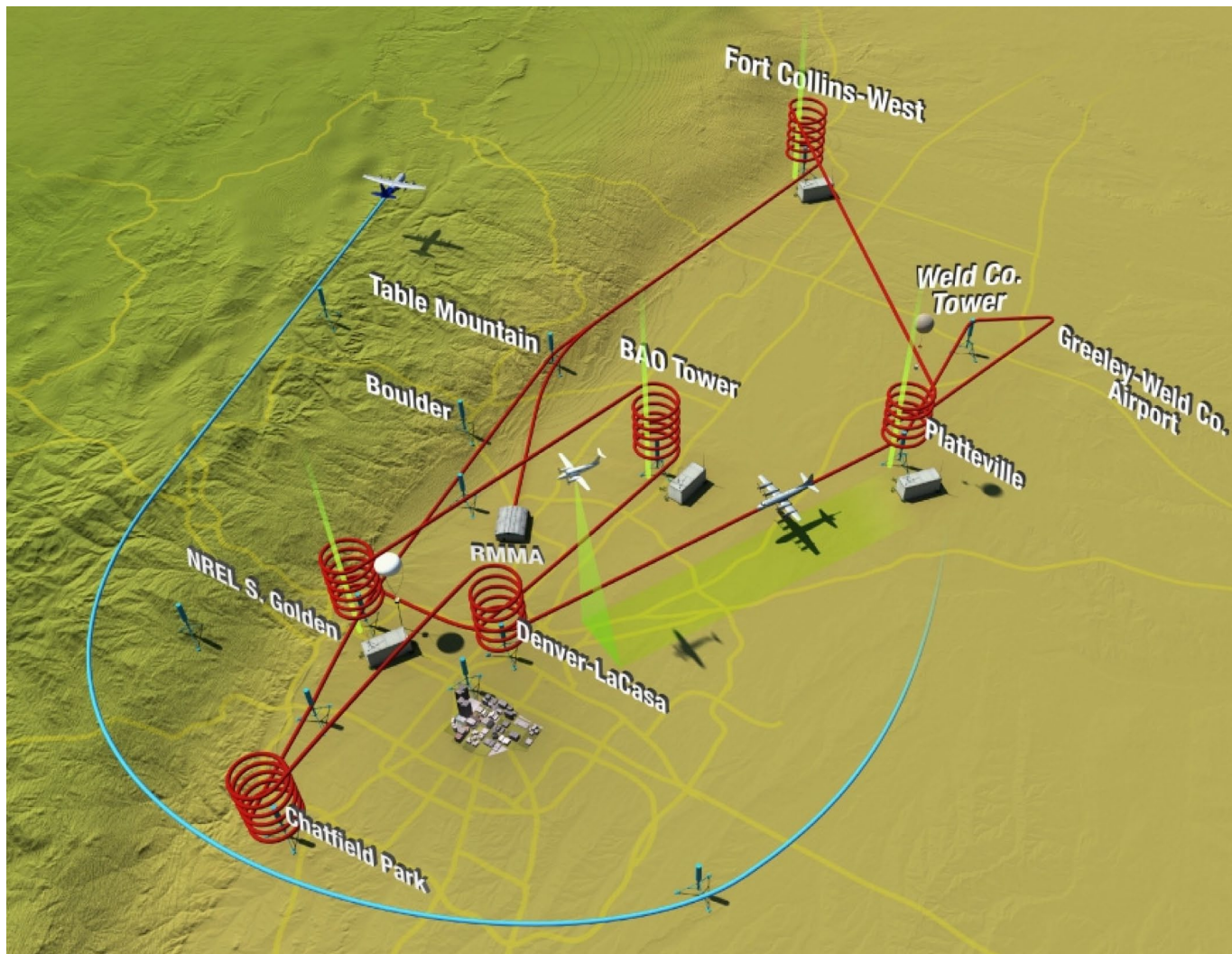


Figure 1. DISCOVER-AQ July 2014 Field Campaign Aircraft Flight Paths

**Table 4. P-3B Aircraft Flight Plan**

Waypoint	Lat deg	Lat min	Lon deg	Lon min	Latitude	Longitude	Speed (m/s)	Delay (min)	Altitude (AGL)	P-Alt (feet)	Comment
RMMA	39	54.5025	-105	6.91704	39.908375	-105.115284	113		0		Takeoff
NOAA-Table Mtn.	40	7.48446	-105	14.21874	40.124741	-105.236979	113		1000		
Fort Collins-West	40	35.5677	-105	8.4846	40.592795	-105.141410	113	15	1000		Spiral up - missed approach before spiral? (airfield closed)
Platteville	40	10.9659	-104	43.566	40.182765	-104.726100	113	15		18000	Spiral down to 1000 ft AGL
Greeley-Weld Co. Airport	40	26.48262	-104	37.87128	40.441377	-104.631188	113		1000		Missed approach
Weld Co. Tower	40	23.1816	-104	44.2467	40.386360	-104.737445	113		1000		
Platteville	40	10.9659	-104	43.566	40.182765	-104.726100	113		1000		
Denver-LaCasa Ncore	39	46.7694	-105	0.3108	39.779490	-105.005180	113		1000		
NREL-S. Table Mtn.	39	44.6235	-105	10.6794	39.743725	-105.177990	113	15	1000		Spiral up to 18000
BAO Tower	40	3.0018	-105	0.2301	40.050030	-105.003835	113	15		18000	Spiral down to 1000 ft AGL
Parkland Airstrip	40	4.25124	-105	1.6518	40.070854	-105.027530	113		1000		Missed Approach
Denver-LaCasa Ncore	39	46.7694	-105	0.3108	39.779490	-105.005180	113	15	1000		Spiral up to 18000
Chatfield Park	39	32.07	-105	4.2219	39.534500	-105.070365	113	15		18000	Spiral down to 1000 ft AGL
Welch	39	38.3268	-105	8.3706	39.638780	-105.139510	113		1000		
NREL-S. Table Mtn.	39	44.6235	-105	10.6794	39.743725	-105.177990	113		1000		
NOAA-Table Mtn.	40	7.48446	-105	14.21874	40.124741	-105.236979	113		1000		
Fort Collins-West	40	35.5677	-105	8.4846	40.592795	-105.141410	113	15	1000		Spiral up - missed approach before spiral? (airfield closed)
Platteville	40	10.9659	-104	43.566	40.182765	-104.726100	113	15		18000	Spiral down to 1000 ft AGL
Greeley-Weld Co. Airport	40	26.48262	-104	37.87128	40.441377	-104.631188	113		1000		Missed approach
Weld Co. Tower	40	23.1816	-104	44.2467	40.386360	-104.737445	113		1000		
Platteville	40	10.9659	-104	43.566	40.182765	-104.726100	113		1000		
Denver-LaCasa Ncore	39	46.7694	-105	0.3108	39.779490	-105.005180	113		1000		
NREL-S. Table Mtn.	39	44.6235	-105	10.6794	39.743725	-105.177990	113	15	1000		Spiral up to 18000
BAO Tower	40	3.0018	-105	0.2301	40.050030	-105.003835	113	15		18000	Spiral down to 1000 ft AGL
Parkland Airstrip	40	4.25124	-105	1.6518	40.070854	-105.027530	113		1000		Missed Approach
Denver-LaCasa Ncore	39	46.7694	-105	0.3108	39.779490	-105.005180	113	15	1000		Spiral up to 18000
Chatfield Park	39	32.07	-105	4.2219	39.534500	-105.070365	113	15		18000	Spiral down to 1000 ft AGL
Welch	39	38.3268	-105	8.3706	39.638780	-105.139510	113		1000		
NREL-S. Table Mtn.	39	44.6235	-105	10.6794	39.743725	-105.177990	113		1000		
NOAA-Table Mtn.	40	7.48446	-105	14.21874	40.124741	-105.236979	113		1000		

**Table 4. P-3B Aircraft Flight Plan (continued)**

Waypoint	Lat deg	Lat min	Lon deg	Lon min	Latitude	Longitude	Speed (m/s)	Delay (min)	Altitude (AGL)	P-Alt (feet)	Comment
Fort Collins-West	40	35.5677	-105	8.4846	40.592795	-105.141410	113	15	1000		Spiral up - missed approach before spiral? (airfield closed)
Platteville	40	10.9659	-104	43.566	40.182765	-104.726100	113	15		18000	Spiral down to 1000 ft AGL
Greeley-Weld Co. Airport	40	26.48262	-104	37.87128	40.441377	-104.631188	113		1000		Missed approach
Weld Co. Tower	40	23.1816	-104	44.2467	40.386360	-104.737445	113		1000		
Platteville	40	10.9659	-104	43.566	40.182765	-104.726100	113		1000		
Denver-LaCasa Ncore	39	46.7694	-105	0.3108	39.779490	-105.005180	113		1000		
NREL-S. Table Mtn.	39	44.6235	-105	10.6794	39.743725	-105.177990	113	15	1000		Spiral up to 18000
BAO Tower	40	3.0018	-105	0.2301	40.050030	-105.003835	113	15		18000	Spiral down to 1000 ft AGL
Parkland Airstrip	40	4.25124	-105	1.6518	40.070854	-105.027530	113		1000		Missed Approach
Denver-LaCasa Ncore	39	46.7694	-105	0.3108	39.779490	-105.005180	113	15	1000		Spiral up to 18000
Chatfield Park	39	32.07	-105	4.2219	39.534500	-105.070365	113	15		18000	Spiral down to 1000 ft AGL
Welch	39	38.3268	-105	8.3706	39.638780	-105.139510	113		1000		
NREL-S. Table Mtn.	39	44.6235	-105	10.6794	39.743725	-105.177990	113		1000		
RMMA	39	54.5025	-105	6.91704	39.908375	-105.115284	113		0		Landing



Figure 2. P-3B Aircraft

Table 5. Beechcraft 200 King Air (UC-12B) Aircraft Flight Plan

Waypoint	Lat deg	Lat min	Lon deg	Lon min	Latitude	Longitude	Speed (m/s)	Delay (min)	Altitude (AGL)	P-Alt (feet)	Comment
RMMA	39	54.5025	-105	6.91704	39.908375	-105.115284	113		0		Takeoff
NOAA-Table Mtn.	40	7.48446	-105	14.21874	40.124741	-105.236979	113		1000		
Fort Collins-West	40	35.5677	-105	8.4846	40.592795	-105.141410	113	15	1000		Spiral up - missed approach before spiral? (airfield closed)
Platteville	40	10.9659	-104	43.566	40.182765	-104.726100	113	15		18000	Spiral down to 1000 ft AGL
Greeley-Weld Co. Airport	40	26.48262	-104	37.87128	40.441377	-104.631188	113		1000		Missed approach
Weld Co. Tower	40	23.1816	-104	44.2467	40.386360	-104.737445	113		1000		
Platteville	40	10.9659	-104	43.566	40.182765	-104.726100	113		1000		
Denver-LaCasa Ncore	39	46.7694	-105	0.3108	39.779490	-105.005180	113		1000		
NREL-S. Table Mtn.	39	44.6235	-105	10.6794	39.743725	-105.177990	113	15	1000		Spiral up to 18000
BAO Tower	40	3.0018	-105	0.2301	40.050030	-105.003835	113	15		18000	Spiral down to 1000 ft AGL
Parkland Airstrip	40	4.25124	-105	1.6518	40.070854	-105.027530	113		1000		Missed Approach
Denver-LaCasa Ncore	39	46.7694	-105	0.3108	39.779490	-105.005180	113	15	1000		Spiral up to 18000

**Table 5. Beechcraft 200 King Air (UC-12B) Aircraft Flight Plan (continued)**

Waypoint	Lat deg	Lat min	Lon deg	Lon min	Latitude	Longitude	Speed (m/s)	Delay (min)	Altitude (AGL)	P-Alt (feet)	Comment
Chatfield Park	39	32.07	-105	4.2219	39.534500	-105.070365	113	15		18000	Spiral down to 1000 ft AGL
Welch	39	38.3268	-105	8.3706	39.638780	-105.139510	113		1000		
NREL-S. Table Mtn.	39	44.6235	-105	10.6794	39.743725	-105.177990	113		1000		
NOAA-Table Mtn.	40	7.48446	-105	14.21874	40.124741	-105.236979	113		1000		
Fort Collins-West	40	35.5677	-105	8.4846	40.592795	-105.141410	113	15	1000		Spiral up - missed approach before spiral? (airfield closed)
Platteville	40	10.9659	-104	43.566	40.182765	-104.726100	113	15		18000	Spiral down to 1000 ft AGL
Greeley-Weld Co. Airport	40	26.48262	-104	37.87128	40.441377	-104.631188	113		1000		Missed approach
Weld Co. Tower	40	23.1816	-104	44.2467	40.386360	-104.737445	113		1000		
Platteville	40	10.9659	-104	43.566	40.182765	-104.726100	113		1000		
Denver-LaCasa Ncore	39	46.7694	-105	0.3108	39.779490	-105.005180	113		1000		
NREL-S. Table Mtn.	39	44.6235	-105	10.6794	39.743725	-105.177990	113	15	1000		Spiral up to 18000
BAO Tower	40	3.0018	-105	0.2301	40.050030	-105.003835	113	15		18000	Spiral down to 1000 ft AGL
Parkland Airstrip	40	4.25124	-105	1.6518	40.070854	-105.027530	113		1000		Missed Approach
Denver-LaCasa Ncore	39	46.7694	-105	0.3108	39.779490	-105.005180	113	15	1000		Spiral up to 18000
Chatfield Park	39	32.07	-105	4.2219	39.534500	-105.070365	113	15		18000	Spiral down to 1000 ft AGL
Welch	39	38.3268	-105	8.3706	39.638780	-105.139510	113		1000		
NREL-S. Table Mtn.	39	44.6235	-105	10.6794	39.743725	-105.177990	113		1000		
NOAA-Table Mtn.	40	7.48446	-105	14.21874	40.124741	-105.236979	113		1000		
Fort Collins-West	40	35.5677	-105	8.4846	40.592795	-105.141410	113	15	1000		Spiral up - missed approach before spiral? (airfield closed)
Platteville	40	10.9659	-104	43.566	40.182765	-104.726100	113	15		18000	Spiral down to 1000 ft AGL
Greeley-Weld Co. Airport	40	26.48262	-104	37.87128	40.441377	-104.631188	113		1000		Missed approach
Weld Co. Tower	40	23.1816	-104	44.2467	40.386360	-104.737445	113		1000		
Platteville	40	10.9659	-104	43.566	40.182765	-104.726100	113		1000		
Denver-LaCasa Ncore	39	46.7694	-105	0.3108	39.779490	-105.005180	113		1000		
NREL-S. Table Mtn.	39	44.6235	-105	10.6794	39.743725	-105.177990	113	15	1000		Spiral up to 18000
BAO Tower	40	3.0018	-105	0.2301	40.050030	-105.003835	113	15		18000	Spiral down to 1000 ft AGL
Parkland Airstrip	40	4.25124	-105	1.6518	40.070854	-105.027530	113		1000		Missed Approach
Denver-LaCasa Ncore	39	46.7694	-105	0.3108	39.779490	-105.005180	113	15	1000		Spiral up to 18000
Chatfield Park	39	32.07	-105	4.2219	39.534500	-105.070365	113	15		18000	Spiral down to 1000 ft AGL
Welch	39	38.3268	-105	8.3706	39.638780	-105.139510	113		1000		
NREL-S. Table Mtn.	39	44.6235	-105	10.6794	39.743725	-105.177990	113		1000		
RMMA	39	54.5025	-105	6.91704	39.908375	-105.115284	113		0		Landing





Figure 3. Beechcraft 200 King Air (UC-12B) Aircraft

# APPENDIX C

**Table 6. DISCOVER-AQ Site Locations: July 2014 Field Campaign (Denver, CO)**

Site Locations: South to North (latitude)	Owner	Latitude	Longitude	Altitude (ft)	Altitude (m)
North Fork Fire Dept	CDPHE	Altitude (m)	-105.24493	7620	2323
Daniels Park	CDPHE	39.4822	-104.9306	6491	1978
<a href="#">Chatfield Park</a>	CDPHE	39.534488	-105.070358	5498	1676
<a href="#">Aurora East/DU-ARTI</a>	CDPHE	39.638540	-104.569130	5912	1802
<a href="#">Welch</a>	CDPHE	39.638780	-105.139510	5719	1743
<a href="#">Squaw Mtn</a>	CDPHE	39.679690	-105.493284	11456	3492
<a href="#">I-25 Denver</a>	CDPHE/EPA	39.732146	-105.015317	5207	1587
<a href="#">NREL-Golden</a>	CDPHE	39.743725	-105.177990	6015	1833
<a href="#">CAMP</a>	CDPHE	39.751190	-104.987610	5226	1593
Centennial Cone	NASA	39.760299	-105.360728	7850	2393
Golden Gate Fire Dept	CDPHE	39.776725	-105.36815	8045	2452
<a href="#">Denver-LaCasa (NCORE)</a>	CDPHE	39.779490	-105.005180	5254	1601
Colorado Mines Peak	CDPHE	39.794099	-105.764158	12458	3805
Welby	CDPHE	39.838200	-104.949845	5105	1556
Fritz Peak	CDPHE	39.908062	-105.491687	8797	2681
<a href="#">Rocky Flats - N</a>	CDPHE	39.912795	-105.188575	5915	1803
South Boulder Creek	CDPHE	39.957205	-105.238460	5483	1671
<a href="#">Boulder</a>	NOAA	39.991859	-105.261325	5447	1660
<a href="#">Niwot Ridge</a>	NOAA	40.031795	-105.533313	9467	2886
<a href="#">BAO Tower</a>	NOAA	40.050030	-105.003835	5196	1584
Parkland Airport	NASA	40.070854	-105.027530	5053	1540
<a href="#">Table Mountain</a>	NOAA	40.124741	-105.236979	5535	1687
<a href="#">Platteville</a>	NOAA	40.182765	-104.726100	4997	1523
<a href="#">Weld Co. Tower</a>	CDPHE	40.386360	-104.737445	4869	1484
Jackson Reservoir State Park	CDPHE	40.38815	-104.09461	4467	1362
Greeley-Weld Co. Airport	NASA	40.441377	-104.631188	4672	1424
Fort Collins-CSU	CDPHE	40.577470	-105.078920	5002	1525
<a href="#">Fort Collins-West</a>	CDPHE	40.592543	-105.141122	5156	1572

**Table 7. DISCOVER-AQ Site-to-Site Distances (North-to-South)**

<b>Locations: South to North (via latitude)</b>	<b>SITE OWNER</b>	<b>FROM</b>	<b>TO</b>	<b>DISTANCE (miles)</b>	<b>Kilometers</b>
North Fork Fire Dept	CDPHE	North Fork Fire Dept	Daniels Park	18.743	30.164
Daniels Park	CDPHE	Daniels Park	Chatfield Park	8.285	13.331
Chatfield Park	CDPHE	Chatfield Park	Aurora East/DU-ARTI	27.656	44.497
Aurora East/DU-ARTI	CDPHE	Aurora East/DU-ARTI	Welch	30.366	48.857
Welch	CDPHE	Welch	Squaw Mtn	19.04	30.634
Squaw Mtn	CDPHE	Squaw Mtn	I-25 Denver	25.678	41.315
I-25 Denver	CDPHE/EPA	I-25 Denver	NREL-Golden	8.685	13.973
NREL-Golden	CDPHE	NREL-Golden	CAMP	10.133	16.303
CAMP	CDPHE	CAMP	Centennial Cone	19.84	31.922
Centennial Cone	NASA	Centennial Cone	Golden Gate Fire Dept	1.202	1.934
Golden Gate Fire Dept	CDPHE	Golden Gate Fire Dept	Denver-LaCasa Ncore	19.286	31.029
Denver-LaCasa Ncore	CDPHE	Denver-LaCasa Ncore	Colorado Mines Peak	40.332	64.892
Colorado Mines Peak	CDPHE	Colorado Mines Peak	Welby	43.348	69.744
Welby	CDPHE	Welby	Fritz Peak	29.151	46.903
Fritz Peak	CDPHE	Fritz Peak	Rocky Flats - N	16.077	25.866
Rocky Flats - N	CDPHE	Rocky Flats - N	South Boulder Creek	4.052	6.519
South Boulder Creek	CDPHE	South Boulder Creek	Boulder	2.685	4.319
Boulder	NOAA	Boulder	Niwot Ridge	14.644	23.593
Niwot Ridge	NOAA	Niwot Ridge	BAO Tower	28.052	45.134
BAO Tower	NOAA	BAO Tower	Parkland Airport	1.909	3.071
Parkland Airport	NASA	Parkland Airport	Table Mountain	11.686	18.802
Table Mountain	NOAA	Table Mountain	Platteville	27.291	43.909
Platteville	NOAA	Platteville	Weld Co. Tower	14.088	22.666
Weld Co. Tower	CDPHE	Weld Co. Tower	Jackson Reservoir SP	33.85	54.462
Jackson Reservoir SP	CDPHE	Jackson Reservoir SP	Greeley-Weld Co. Airport	28.482	45.825
Greeley-Weld Co. Airport	NASA	Greeley-Weld Co. Airport	Fort Collins-CSU	25.344	40.778
Fort Collins-CSU	CDPHE	Fort Collins-CSU	Fort Collins-West	3.448	5.547
Fort Collins-West	CDPHE	Fort Collins-West	Fort Collins-West	0	0



# APPENDIX D

## Notes:

1. Sites were grouped together by geographic proximity for site visits (when collecting site information) in order to minimize travel distance and time between sites.
2. **Sites are listed below in the order that they were visited/visit attempted.**
3. Dates of site visits were from 28 July 2014 through 31 July 2014 (inclusive).
4. Point-of-contact name and phone information was researched and assigned for each individual site.
5. **Locations of sites were verified by multiple methods:** a) use of Google Earth to locate remote and/or mountain-based sites without designated street addresses; b) calling site point-of-contact (where available), and; c) verifying location and MapQuest directions.

### Site 1: Centennial Cone

Owner: CDPHE

Description: N/A



Figure 4. Centennial Cone View #1



Figure 4. Centennial Cone View #2

**Location/Address:** 2234 Douglas Mountain Drive, Golden, Colorado 80403; (Centennial Cone Park, US 6, Golden Gate Canyon Colorado 80403)

**Directions:** From 14700 W. 6th Avenue Frontage Road, Golden, Colorado 80403

- Get on US-6 W, in West Pleasant View, follow for 0.7 miles
- Follow I-70 W to US-6 E in Clear Creek County for 17.2 miles. Take exit 244 from I-70 W
- Continue on US-6 E. Drive to Centennial Cone Road in Jefferson County for 4.7 miles
- Arrive at 2234 Douglas Mountain Drive

**Note 1:** Location near Highway 6/Grand Army of the Republic Highway/I-70

**Note 2:** Location near Golden Gate Fire Department Site

**Latitude:** 39.760299 (39°45'37.0764")

**Longitude:** -105.360728 (-105°21'38.6208")

**Altitude:** 7850 ft (2392.68 m)

**Site Contact:** N/A

Equipment	Power Req	Dimensions	Number of Units	Comments
Pandora	N/A	N/A	1	
O <sub>3</sub> Monitor	N/A	N/A	1	

**Site 2: Golden Gate Fire Department (Station #1)**

**Owner:** CDPHE

**Description:** N/A



Figure 5. Golden Gate Fire Department (Station #1) View #1

**Location/Address:** 32360 Robinson Hill Road, Golden Colorado 80403

**Directions:** From Centennial Cone Park

- Head 3.6 miles west on US-6 W
- Slight right onto CO-119 for 0.3 miles
- Turn right onto Douglas Mountain Drive, follow for 4.4 miles
- Turn right onto Robinson Hill Road
- In 0.2 miles, arrive at 32360 Robinson Hill Road

**Note 1:** Located 1.202 miles from Centennial Cone Site

**Note 2:** Nearby Main Fire Department Site (7181 Crawford Gulch Road, Golden, Colorado 80403)

**Latitude:** 39.776725 (39°46'36.2100")

**Longitude:** -105.36815 (-105°22'05.3400")

**Altitude:** 8045 ft (2452.12 m)

**Site Contact:** 303-279-3538

Equipment	Power Req	Dimensions	Number of Units	Comments
O <sub>3</sub> Monitor	N/A	N/A	1	

**Site 3: Fritz Peak (NOAA Aeronomy Observatory)**

**Owner:** CDPHE

**Description:** N/A



Figure 6. Fritz Peak (NOAA Aeronomy Observatory) View #1

**Location/Address:** Gilpin County, Colorado 80422

**Directions:** From 32360 Robinson Hill Road, Golden Colorado 80403

- Head east on Robinson Hill Road toward CII Louisa for 1.0 miles
- Turn left, stay on Robinson Hill Road, follow for 1.1 miles
- Turn left onto Golden Gate Canyon Road, follow for 9.8 miles
- Turn right onto CO-119, follow for 6.6 miles
- Turn right, follow for 0.2 miles
- Arrive at Fritz Peak

**Note 1:** Location is approximately 6 miles west of Golden Colorado

**Note 2:** Location is 16.077 miles from Rocky Flats

**Longitude:** 39.908062 (39°54'29.0232")

**Latitude:** -105.491687 (-105°29'30.0732")

**Altitude:** 8797 ft (2681.326 m)

**Site Contact:** 303-497-3436

Equipment	Power Req	Dimensions	Number of Units	Comments
Pandora	N/A	N/A	1	
O <sub>3</sub> Monitor	N/A	N/A	1	

#### Site 4: Colorado Mines Peak

**Owner:** CDPHE

**Description:** N/A



Figure 7. Colorado Mines Peak View #1

**Location/Address:** Colorado Mines Peak, Berthoud Pass Heliport [closest address], Idaho Springs, Colorado 80452

**Directions:** From Fritz Peak

- Head south toward CO-119
- For 46.9 miles, continue on CO-119. Drive from Casino Parkway, I-70, and US-40W to Clear Creek County.
- Drive to destination in 1.9 miles
- Arrive at Berthoud Pass Heliport (Idaho Springs, CO 80452)

**Note 1:** Colorado Mines Peak is contained within the Arapaho National Forest (part of the Arapaho-Roosevelt National Forests and Pawnee National Grasslands [ARP]) on Berthoud Pass and is approximately 24 miles (38,624 km) west of Idaho Springs, Colorado (on 40/I-70)

**Note 2:** Location is 43.348 miles from Welby

**Latitude:** 39.794099 (39°47'38.7564")

**Longitude:** -105.764158 (-105°45'50.9688")

**Altitude:** 12458 ft (3797.1984 m)

**Site Contact:** Local Forest Range-Sulphur Ranger District: 970-887-4100/303-643-4880; Local Forest Ranger-Floral Park Campground: Idaho Springs: 303-567-2901

Equipment	Power Req	Dimensions	Number of Units	Comments
Pandora	N/A	N/A	1	
O <sub>3</sub> Monitor	N/A	N/A	1	

#### Site 5: Squaw Mountain

**Owner:** CDPHE

**Description:** N/A



Figure 8. Squaw Mountain View #1

**Location/Address:** Squaw Mountain, Forest Service 192.1, Arapaho National Forest, Idaho Springs, Colorado 80452

**Directions:** From Colorado Mines Peak, Berthoud Pass Heliport, Idaho Springs, Colorado 80452

- Head west toward Loop Trail, follow for 1.9 miles
- Turn left toward US-40 E, then in 144 feet turn left onto US-40 E
- In 15.1 miles, merge onto I-70 E/US-40 E. Follow for 7.2 miles
- Take exit 240 for CO-103 towards Mt Evans
- In 486 ft, turn right onto CO-103 S/Chicago Creek Rd. Follow for 18.8 miles
- Turn right onto Fire Tower Trail/ Forest Service 192.1. Follow for 0.7 miles
- Arrive at Forest Service 192.1, Idaho Springs, CO 80452

**Note 1:** Squaw Mountain is contained within the Arapaho National Forest (part of the Arapaho-Roosevelt National Forests and Pawnee National Grasslands [ARP]) and is approximately 30 miles west of Denver, Colorado

**Note 2:** Local Forest Ranger station is available on-site and duty ranger/phone is available

**Note 3:** Regional Forest Ranger Station is located as shown below: 2150 Centre Avenue, Building E, Fort Collins, CO 80526-8119

**Note 4:** Location is 25.678 miles to I-25 Denver

**Latitude:** 39.679690 (39°40'46.8840")

**Longitude:** -105.493284 (-105°29'35.8224")

**Altitude:** 11456 ft (3491.7888 m)

**Site Contact:** Local Forest Ranger: 303-567-3000; Regional Forest Ranger: 970-295-6600

Equipment	Power Req	Dimensions	Number of Units	Comments
O <sub>3</sub> Monitor	N/A	N/A	1	
Aeronet	N/A	N/A	1	
Pandora	N/A	N/A	1	



**Site 6: North Fork Fire Department****Owner:** CDPHE**Description:** N/A**Figure 9. North Fork Fire Department View #1****Location/Address:** Fire Station #1, 19345 County Road 126, Buffalo Creek Colorado 80425**Directions:** From Forest Service 192.1, Arapaho National Forest, Idaho Springs, Colorado 80452

- Head west on Fire Tower Trail/Forest Service 192.1 toward Forest Service Road 252.1 D
- Continue of Squaw Pass Rd. Take CO Road 73/County Highway 73, US-285 S and Pine Valley Road to Deckers Road in Jefferson County. Follow for 44.4 miles
- Arrive at 19345 County Road 126, Pine CO 80470

**Note 1:** Main Station/HQ Location: 16675 County Road 126, Pine, Colorado 80470**Note 2:** Location is 18.743 miles from Daniels Park**Latitude:** 39.3616 (39°21'41.7600")**Longitude:** -105.24493 (-105°14'41.7480")**Altitude:** 7620 ft (2322.576 m)**Site Contact:** 303-838-2270

Equipment	Power Req	Dimensions	Number of Units	Comments
O <sub>3</sub> Monitor	N/A	N/A	1	

**Site 7: BAO Tower****Owner:** NOAA**Description:** NOAA Site**Figure 10. BAO Tower View #1****Figure 10. BAO Tower View #2****Location/Address:** Erie Parkway and County Road 5, Erie Colorado 80516**Directions:** From 14700 W. 6th Avenue Frontage Road, Golden Colorado 80403

- Get on I-70 E in West Pleasant View from Denver West Colorado Mills Blvd and I-70 Business/W Colfax. Follow for 1.1 miles
- Continue on I-70 E. Take I-25 N to Summit Blvd in Broomfield. In 28.6 miles, take exit 232 from I-25 N
- Drive to Erie Parkway in Weld County. Follow for 1.1 miles
- Arrive at County Road 7 and Erie Parkway, Erie, CO 80516

**Note 1:** Site is near Erie High School, Erie, Colorado**Note 2:** Erie Colorado sits in both Weld County [80504] and Boulder County [80026]**Note 3:** Location is approximately 51 miles southwest of Greeley, Colorado**Note 4:** Location is approximately 2 miles northwest of (Parkland Airport) Erie, Colorado 80516**Note\*\*:** This site was a spiral overflight location for the DISCOVER-AQ aircraft.**Latitude:** 40.050030 (40°03'00.1080")**Longitude:** -105.003835 (-105°00'13.8060")**Altitude:** 5196 ft (1584 m)**Site Contact:** Dan Wolfe: 303-497-6207; Security: 303-497-3530

Equipment	Power Req	Dimensions	Number of Units	Comments
Cairclips O <sub>3</sub> /NO <sub>2</sub>	Solar power	36 x 62 mm	4	Small air pollution sensor: (EPA evaluation activity) At GL, 100 m, 200 m, 300 m
Cairclips NO <sub>2</sub>	Solar power	36 x 62 mm	4	Small air pollution sensor: (EPA evaluation activity) At GL, 100 m, 200 m, 300 m
Aeroqual O <sub>3</sub>	12V adapter	195 x 122 x 54 mm	1	Small air pollution sensor: (EPA evaluation activity) At GL
AQMesh	Lithium ion battery	4.6 x 7.0 x 5.5 in	4	Small air pollution sensor: (EPA evaluation activity) At GL, 100 m, 200 m, 300 m
NOAA-TOPAZ Lidar and HRDL	N/A	N/A	1	
UW-HSRL, H <sub>2</sub> O DIAL	N/A	N/A	1	
Aeronet	N/A	N/A	1	
Pandora	N/A	N/A	2	

### Site 8: Parkland Airport

**Owner:** NASA

**Description:** N/A



Figure 11. Parkland Airport View #1



Figure 11. Parkland Airport View #2

**Location/Address:** Parkland Airport, Erie Colorado 80516

**Directions:** From Erie Parkway/Weld County Road 8/Leon A. Whurl Parkway and County Road 7

- Head west on Erie Parkway/Weld County Road 8 for 1.0 miles
- Turn right onto County Road 5. Follow for 2.0 miles
- Turn left onto County Road 12
- In 0.5 miles, turn left onto Bonnie Circle.
- In 0.1 miles, arrive at Parkland Airport-7CO0, Erie, CO 80516

**Note 1:** Location is approximately 2 miles southeast of BAO Tower, Erie, Colorado 80516

**Note 2:** Location is 11.686 miles from Table Mountain

**Note\*\*:** This was a 500-foot altitude ‘missed approach’ location for the DISCOVER-AQ aircraft, therefore it had no ground-based monitoring equipment.

**Latitude:** 40.070854 (40°04’15.0744’’)

**Longitude:** -105.027530 (-105°01’39.1080’’)

**Altitude:** 5053 ft (1540.154 m)

**Site Contact:** Steven Schneider (Manager): 303-828-3052

### Site 9: Platteville

**Owner:** NOAA

**Description:** NOAA Site



Figure 12. Platteville View #1

Figure 12. Platteville View #2

**Location/Address:** [Closest Address] Fort Vasquez Museum. 13412 US 85, Platteville, Colorado 80651.  
[Closest Intersection] US 85 and County Road 28, Platteville Colorado 80651

**Directions:** From Parkland Airport, Erie, Colorado 80516 (to US 85 and Weld County Road 28)

- Take County Road 5 to CO-52 E. Follow for 1.6 miles
- Take I-25 N and Highway 66 E to County Road 28. Follow for 19.8 miles
- Turn left, arrive at County Road 28, Platteville, CO 80651
- Proceed approximately 15 miles until you see a ‘fork’ in the road, turn right at the ‘fork’ and proceed approximately 3 miles and reach facility outer perimeter/gate

**Note 1:** Weigh Station is on the left lane of road

**Summer Hours:** 10:00 AM-4:00 PM (7 days)

**Winter Hours:** 10:00 AM-4:00 PM (5 days)

**Note 2:** Location is approximately 17 miles south of Greeley, Colorado

**Note 3:** Location is 14.088 miles from Weld County Tower

**Note\*\*:** This site was a spiral overflight location for the DISCOVER-AQ aircraft.

**Latitude:** 40.182765 (40°10’57.9540’’)

**Longitude:** -104.726100 (-104°43’33.9600’’)

**Altitude:** 4997 ft (1523.086 m)

**Site Contact:** On-Duty Museum Curator (Fort Vasquez Museum): 970-785-2832

Equipment	Power Req	Dimensions	Number of Units	Comments
CAPS NO <sub>2</sub>	N/A	N/A	1	
O <sub>3</sub> Monitor	N/A	N/A	1	
CRDS NO <sub>2</sub>	N/A	N/A	1	
NO <sub>x</sub> /NO <sub>y</sub>	N/A	N/A	1	
SO <sub>2</sub>	N/A	N/A	1	
CO	N/A	N/A	1	
CO <sub>2</sub> /CH <sub>4</sub>	N/A	N/A	1	
NMHC	N/A	N/A	1	
Ozonesondes	N/A	N/A	multiple	
Aeronet	N/A	N/A	1	
Pandora	N/A	N/A	1	

**Site 10: Jackson [Reservoir] Lake State Park**  
**Owner: CDPHE**



**Figure 13. Jackson (Reservoir) Lake State Park View #1**

**Location/Address:** Jackson Lake State Park, 26363 County Road 3 (MCR 3), Orchard Colorado 80649

**Directions:** From US 85 and Weld County Road 28, Platteville, Colorado 80651

- Get on I-76 in Hudson from County Road 32, County Road 41, County Road 22, and County Road 49
- Follow I-76 E to CO-52E in Morgan County. In 31.4 miles, take exit 66A from I-76 E
- Take CO-39 N to County Road 3/County Road 300. Follow for 9.4 miles
- Arrive at Jackson Lake State Park

**Note 1:** Jackson Reservoir is located inside Jackson Lake State Park

**Note 2:** Location is approximately 35 miles east of Greeley, Colorado

**Note 3:** Location is 28.482 miles from Greeley-Weld County Airport

**Latitude:** 40.38815 (40°23'17.3400")

**Longitude:** -104.09461 (-104°05'40.5960")

**Altitude:** 4467 ft (1361.542)

**Site Contact:** 970-65-2551

Equipment	Power Req	Dimensions	Number of Units	Comments
O <sub>3</sub> Monitor	N/A	N/A	1	

**Site 11: Greeley–Weld County Tower**  
**Owner: CDPHE**

**Description:** CDPHE, 08-123-0009



**Figure 14. Greeley-Weld County Tower View #1**

**Figure 14. Greeley-Weld County Tower View #2**

**Location/Address:** 3101 35<sup>th</sup> Avenue, Greeley Colorado 80634

**Directions:** From Jackson Lake State Park, 26363 County Road 3 (MCR 3), Orchard, Colorado 80649

- Take CO-144 W to US-34 W. Follow for 9.6 miles
- Follow US-34 W to 35th Avenue in Greeley for 34.1 miles.
- Turn left onto 35th Avenue
- Arrive at Greeley County Tower, 3101 35th Avenue, Greeley, Colorado 80634

**Note 1:** Location is approximately 32.43 miles east of Fort Collins, Colorado

**Note 2:** Location is approximately 8.04 miles southwest of Greeley-Weld County Airport, Greeley, Colorado

**Note 3:** Location is 33.85 miles from Jackson Reservoir SP

**Note\*\*:** This site was an overflight location for the DISCOVER-AQ aircraft.

**Latitude:** 40.386360 (40°23'10.8960")

**Longitude:** -104.737445 (-104°44'14.8020")

**Altitude:** 4869 ft (1484.071 m)

**Site Contact:** Garry Kaufman (Air Quality Division Deputy Director): 303-692-3269; Lisa Devore (Air Quality Issues): 303-692-3117

Equipment	Power Req	Dimensions	Number of Units	Comments
O <sub>3</sub> Monitor	N/A	N/A	1	
Wind Speed, Wind Direction, Temperature	N/A	N/A	1	
Aeronet	N/A	N/A	1	
Pandora	N/A	N/A	1	



### Site 12: Greeley-Weld County Airport

**Owner:** NASA

**Description:** N/A



Figure 15. Greeley-Weld County Airport View #1

Figure 15. Greeley-Weld County Airport View #2

**Location/Address:** 600 Airport Road, Greeley Colorado 80631

**Directions:** From 3101 35th Avenue, Greeley, Colorado 80634

- Head north on 35th Avenue toward W 29th Street for 0.4 miles
- Turn right onto US-34 E. Follow for 2.9 miles
- Continue onto US-85 N for 2.3 miles
- Turn right onto E 8th Street. Follow for 2.2 miles
- Turn left onto Airport Road. In 0.3 miles, turn right
- Arrive at Greeley-Weld County Airport, 600 Airport Road, Greeley, Colorado 80631

**Note 1:** Location is approximately 32.43 miles east of Fort Collins, Colorado

**Note 2:** Location is approximately 8.04 miles northeast of Greeley-Weld County Airport, Greeley, Colorado

**Note 3:** Location is 25.344 miles from Fort Collins-CSU

**Latitude:** 40.441377 (40°26'28.9572")

**Longitude:** -104.631188 (-104°37'52.2768")

**Altitude:** 4672 ft (1424.026 m)

**Note\*\*:** This was a 'missed approach' location for the DISCOVER-AQ aircraft, therefore it had no ground-based monitoring equipment.

**Site Contact:** Gary Cyr (Manager): 970-336-3000

### Site 13: Fort Collins-CSU

**Owner:** CDPHE

**Description:** CDPHE, 08-069-1004



Figure 16. Fort Collins-CSU View #1

Figure 16. Fort Collins-CSU View #2

**Location/Address:** 251 Edison Drive, Fort Collins Colorado 80523-6030

**Directions:** From 600 Airport Road, Greeley, Colorado 80631

- Head south on Airport Road toward Skyhawk Drive
- Take US-85 N and CO-14 W to W Pitkin Street in Fort Collins for 32.6 miles
- Continue on W Pitkin Street. Drive to Edison Drive, follow for 0.2 miles
- Arrive at Fort Collins-CSU, 251 Edison Drive, Fort Collins, Colorado 80521

**Note 1:** Location is approximately 32.43 miles west of Greeley, Colorado

**Note 2:** Location is approximately 5.75 miles southeast of Fort Collins-West, Fort Collins, Colorado

**Note 3:** Location is 3.448 miles from Fort Collins-West

**Latitude:** 40.577470 (40°34'38.8920")

**Longitude:** -105.078920 (-105°04'44.1120")

**Altitude:** 5002 ft (1524.61 m)

**Site Contact:** Lori Meyers (Special Events): 970-491-0056; Emilia Parker (Special Events): 970-491-0108

Equipment	Power Req	Dimensions	Number of Units	Comments
O <sub>3</sub> Monitor	N/A	N/A	1	
CO Monitor	N/A	N/A	1	
Wind Speed, Wind Direction, Temperature	N/A	N/A	1	

**Site 14: Fort Collins-West****Owner:** CDPHE**Description:** CDPHE, 08-069-0011**Figure 17. Fort Collins-West View #1****Figure 17. Fort Collins-West View #2****Location/Address:** 3416 W. LaPorte Avenue, Fort Collins Colorado 80521**Directions:** From 251 Edison Drive, Fort Collins, Colorado 80521

- Take East Drive, W Lake Street, and Centre Avenue to W Prospect Road in 0.5 miles
- Continue on W Prospect Road to Laporte Avenue for 4.1 miles
- Continue on Laporte Avenue for 0.4 miles to destination
- Arrive at Fort Collins-West, 3416 Laporte Avenue, Fort Collins, Colorado 80521

**Note 1:** Location is approximately 32.43 miles west of Greeley, Colorado**Note 2:** Location is approximately 5.75 miles northwest of Fort Collins-CSU, Fort Collins, Colorado**Note\*\*:** This site was a spiral overflight location for the DISCOVER-AQ aircraft.**Latitude:** 40.592543 (40°35'33.1548")**Longitude:** -105.141122 (-105°08'28.0392")**Altitude:** 5156 ft (1571.549 m)**Site Contact:** Garry Kaufman (Air Quality Division Deputy Director): 303-692-3269; Lisa Devore (Air Quality Issues): 303-692-3117

Equipment	Power Requirements	Dimensions	Number of Units	Comments
Scrubberless UV O <sub>3</sub>	N/A	N/A	1	
Photolytic NO <sub>2</sub>	N/A	N/A	1	
GFSC TOLNET-O <sub>3</sub> , MPL (LIDAR)	N/A	N/A	1	
Ozonesondes	N/A	N/A	multiple	
T700U Calibrator	N/A	N/A	1	
701H ZAG	N/A	N/A	1	
Envirodat Ultimate	N/A	N/A	1	
Aeronet	N/A	N/A	1	
Pandora	N/A	N/A	1	

**Site 15: NREL (South Table Mountain-Golden)****Owner:** CDPHE**Description:** CDPHE, 08-059-0011**Figure 18. NREL (South Table Mountain) View #1****Location/Address:** 2054 Quaker Street Golden Colorado 80401**Directions:** From 14700 W 6th Avenue Frontage Road, Golden, Colorado 80401

- Head southwest toward Indiana Street for 0.2 miles.
- Turn right onto Indiana Street. Follow for 0.2 miles
- Continue onto Denver West Colorado Mills Boulevard for 0.4 miles
- Continue onto Indiana Street for 0.2 miles
- Continue onto Golden Road. Follow for 0.5 miles
- At the traffic circle, continue straight onto S Golden Road. Follow for 0.5 miles
- At the traffic circle, take the first exit onto Quaker Street. Destination will be on the right in 0.6 miles
- Arrive at NREL, 2054 Quaker Street, Golden, Colorado 80401

**Note 1:** Location is 10.133 miles to CAMP**Note\*\*:** This site was a spiral overflight location for the DISCOVER-AQ aircraft.**Latitude:** 39.743725 (39°44'37.4100")**Longitude:** -105.177990 (-105°10'40.7640")**Altitude:** 6015 ft (1833.372 m)**Site Contact:** Garry Kaufman (Air Quality Division Deputy Director): 303-692-3269; Lisa Devore (Air Quality Issues): 303-692-3117

Equipment	Power Req.	Dimensions	Number of Units	Comments
Cairclip O <sub>3</sub> /NO <sub>2</sub>	Solar power	32 x 62 mm	1 set	Small air pollution sensor: (EPA evaluation activity) Set: (NO <sub>2</sub> and NO <sub>2</sub> + O <sub>3</sub> )
Cairclip NO <sub>2</sub>	Solar power	32 x 62 mm	1	Small air pollution sensor: (EPA evaluation activity)
PE Airbase (ELM)	12 V Adapter	26 x 17 x 7 cm	3	Small air pollution sensor: (EPA evaluation activity)



Equipment	Power Req.	Dimensions	Number of Units	Comments
Aeroqual O <sub>3</sub>	12 V Adapter	195 x 122 x 54 mm	3	Small air pollution sensor: (EPA evaluation activity)
Aeroqual NO <sub>2</sub> /RH/Temp	12 V Adapter	195 x 122 x 54 mm	1	Small air pollution sensor: (EPA evaluation activity)
Scrubberless UV O <sub>3</sub>	N/A	N/A	1	
Photolytic NO <sub>2</sub>	N/A	N/A	1	
CRDS NO <sub>2</sub>	N/A	N/A	1	
T700U Calibrator	N/A	N/A	1	
701H ZAG	N/A	N/A	1	
Envivas Ultimate	N/A	N/A	1	
Bendix 8002 O <sub>3</sub>	N/A	N/A	1	
43i UVF SO <sub>2</sub>	100-115VAC	N/A	1	
T265 O <sub>3</sub>	100V – 120V, 220V – 240V, 50-60Hz	N/A	1	
48i CO	110-115VAC	N/A	1	
T500U NO <sub>2</sub>	80W; 100-250 VAC (50-60 Hz)	N/A	1	
TSI APS	N/A	N/A	1	
Pandoras	N/A	N/A	2	
NO <sub>x</sub> /NO <sub>y</sub>	N/A	N/A	1	
Ecotech NO <sub>y</sub>	N/A	N/A	1	
Ceilometer	110V	N/A	1	
MPL, LaRC TOLNET-O <sub>3</sub> , and Leosphere	N/A	N/A	1	
Tethersonde radiosondes	N/A	N/A	multiple	
sodar	N/A	N/A	1	
Flux tower	N/A	N/A	1	
nephelometer	N/A	N/A	1	
AQMesh	Lithium ion battery	4.6 x 7.0 x 5.5 in	4	Small air pollution sensor: (EPA evaluation activity)

## Site 16: David Skaggs Research Center-Boulder

**Owner:** NOAA

**Description:** NOAA Site



Figure 19. David Skaggs Research Center View #1

Figure 19. David Skaggs Research Center View #2

**Location/Address:** 325 Broadway (David Skaggs Research Center: Broadway and Rayleigh Road), Boulder Colorado 80305

**Directions:** From 2054 Quaker Street, Golden, Colorado, 80401

- Take Ford Street to CO-93 N. Follow for 4.4 miles
- Follow CO-93 N to Broadway in Boulder for 16.3 miles
- Arrive at David Skaggs Research Center, 325 Broadway, Boulder, Colorado 80305

**Note 1:** Location is 14.644 miles to Niwot Ridge

**Note\*\*:** This site was an overflight location for the DISCOVER-AQ aircraft.

**Latitude:** 39.991859 (39°59'30.6924")

**Longitude:** -105.261325 (-105°15'40.7700")

**Altitude:** 5447 ft (1660.246 m)

**Site Contact:** Holly Palm (Secretary) 303-497-6000; Jerry Janssen (Director): 303-497-6643

Equipment	Power Req.	Dimensions	Number of Units	Comments
Pandora	N/A	N/A	1	
Aeronet	N/A	N/A	1	

**Site 17: CAMP**

(Continuous Ambient Monitoring Program)

**Owner:** CDPHE**Description:** CDPHE, 08-031-0002

Figure 20. CAMP (Continuous Ambient Monitoring Program)  
View #1

**Location/Address:** 2105 Broadway Street, Boulder Colorado 80302

**Directions:** From 325 Broadway Street, Boulder, Colorado 80305

- Head southeast on Broadway toward Rayleigh Road
- Take Lashley Lane to Broadway for 0.2 miles
- Turn right onto Broadway
- Take 9th Street to Broadway for 1.1 miles
- Turn right onto Broadway, destination will be on right
- Arrive at CAMP, 2105 Broadway, Boulder, Colorado 80302

**Note 1:** Location is 19.84 miles from Centennial Cone

**Note\*\*:** This site was an overflight location for the DISCOVER-AQ aircraft.

**Latitude:** 39.751190 (39°45'04.2840")

**Longitude:** -104.987610 (-104°59'15.3960")

**Altitude:** 5226 ft (1592.885 m)

**Site Contact:** N/A

Equipment	Power Req	Dimensions	Number of Units	Comments
CAPS NO <sub>2</sub>	N/A	N/A	1	
O <sub>3</sub> Monitor	N/A	N/A	1	
NO <sub>x</sub> /NO <sub>y</sub>	N/A	N/A	1	
SO <sub>2</sub>	N/A	N/A	1	
CO	N/A	N/A	1	
PM <sub>2.5</sub>	N/A	N/A	1	
PM <sub>10</sub>	N/A	N/A	1	
Wind Speed, Wind Direction, Temperature	N/A	N/A	1	

**Site 18: Rocky Flats (North)****Owner:** CDPHE**Description:** CDPHE, 08-059-0006

Figure 21. Rocky Flats View #1

**Location X-1 (go east on 128):** 16600 State Highway 128, Boulder Colorado 80303

**Location X-2 (go south on Indiana):** Indiana Street & County Road 128 Broomfield Colorado 80021

**Note 1:** Location is 4.052 miles from South Boulder Creek

**Note\*\*:** This site was an overflight location for the DISCOVER-AQ aircraft.

**Latitude:** 39.912795 (39°54'46.0620")

**Longitude:** -105.188575 (-105°11'18.8700")

**Altitude:** 5915 ft (1802.89 m)

**Site Contact:** Garry Kaufman (Air Quality Division Deputy Director): 303-692-3269; Lisa Devore (Air Quality Issues): 303-692-3117

Equipment	Power Req	Dimensions	Number of Units	Comments
Pandora	N/A	N/A	1	
O <sub>3</sub> Monitor	N/A	N/A	1	
Aeronet	N/A	N/A	1	
Wind Speed, Wind Direction, Temperature	N/A	N/A	1	

**Site 19: South Boulder Creek****Owner:** CDPHE**Description:** CDPHE, 08-013-0011**Figure 22. South Boulder Creek View #1****Location/Address:** 1405 ½ S. Foothills Highway, Boulder Colorado 80305**Directions:** From 16600 State Highway 128, Boulder, Colorado 80303

- Head southeast on CO-128 E for 144 ft
- Make a U-turn. Follow for 0.3 miles
- Turn right onto CO-93 N. Follow for 2.4 miles
- Turn left onto Thomas Lane
- Arrive at 1405 S Foothills Highway, Boulder, Colorado 80305

**Note 1:** Facility is next to Boulder/Lafayette Wastewater Treatment Plant (WWTP), 3566 Baseline Road, Lafayette, Colorado 80026**Note 2:** Location is 2.685 miles from Boulder**Latitude:** 39.957205 (39°57'25.9380")**Longitude:** -105.238460 (-105°14'18.4560")**Altitude:** 5483 ft (1671.218 m)**Site Contact:** Boulder WWTP: 303-413-7340

Equipment	Power Req	Dimensions	Number of Units	Comments
O <sub>3</sub> Monitor	N/A	N/A	1	

**Site 20: Table Mountain****Owner:** NOAA**Description:** NOAA Site**Figure 23. Table Mountain (NOAA) View #1****Location/Address:** 8600 N. 39th Street, Longmont, Colorado 80503**Directions:** From 1405 ½ S. Foothills Highway, Boulder Colorado 80305

- Head northeast on Thomas Lane toward CO-93 S for 59 feet
- Turn left at the first cross street onto CO-93 N for 4.7 miles
- Continue onto Broadway for 3.4 miles
- Turn left onto US-36 W. Follow for 4.7 miles
- Turn right onto Plateau Road. Follow for 1.0 mile
- Turn left onto N 39th St. Destination will be on the right
- Arrive at 8600 39th Street, Longmont, Colorado 80503

**Note 1:** Location is approximately 21.75 miles west of Boulder, Colorado**Note 2:** Location is 27.291 miles from Platteville**Latitude:** 40.124741 (40°07'29.0676")**Longitude:** -105.236979 (-105°14'13.1244")**Altitude:** 5535 ft (1687.068 m)**Site Contact:** Irina Petropavlovskikh (Ozone/Water Vapor): 303-497-6279

Equipment	Power Req	Dimensions	Number of Units	Comments
Pandora	N/A	N/A	1	
O <sub>3</sub> Monitor	N/A	N/A	1	
Aeronet	N/A	N/A	1	



**Site 21:** Niwot Ridge  
**Owner:** NOAA/UC-Boulder  
**Description:** NOAA Site



Figure 24. Niwot Ridge View #1

**Location/Address:** 818 County Road 116, Nederland, CO 80466

**Directions:** From 8600 N 39th Street, Longmont, Colorado 80503

- Follow Plateau Road to US-36 W for 1.0 mile
- Follow Left hand Canyon Drive and Co-72 E to County Road 116 for 21.7 miles
- Turn right onto County Road 116. Destination will be on the right
- Arrive at Niwot Ridge, 818 County Road 116, Nederland, Colorado 80466

**Note 1:** Location is 28.052 miles from BAO Tower

**Latitude:** 40.031795 (40°01'54.4620")

**Longitude:** -105.533313 (-105°31'59.9268")

**Altitude:** 9467 ft (2885.512 m)

**Site Contact:** 303-492-8841

Equipment	Power Req	Dimensions	Number of Units	Comments
Pandora	N/A	N/A	1	
Aeronet	N/A	N/A	1	

**Site 22:** Daniels Park  
**Owner:** CDPHE  
**Description:** N/A



Figure 25. Daniels Park View #1



Figure 25. Daniels Park View #2

**Location/Address:** 8699 North Daniels Park Road, Sedalia Colorado 80135

**Directions:** From 14700 W 6th Avenue Frontage Road, Golden, Colorado 80403

- Get on US-6 W for 0.4 miles
- Take CO-470 E to S University Boulevard in Highlands Ranch. Take the CO-177/University Boulevard exit from CO-470 E for 25.0 miles
- Continue on S University Boulevard. Take Fairview Parkway to Daniels Park Road for 6.0 miles
- Arrive at 8699 N Daniels Park Road, Sedalia, Colorado 80135

**Note 1:** Location is 8.285 miles from Chatfield Park

**Latitude:** 39.3616 (39°21'41.7600")

**Longitude:** -105.24493 (-105°14'41.7480")

**Altitude:** 7620 ft (2322.576 m)

**Site Contact:** 720-865-0900

Equipment	Power Req	Dimensions	Number of Units	Comments
O <sub>3</sub> Monitor	N/A	N/A	1	

**Site 23: Chatfield Park****Owner:** CDPHE**Description:** CDPHE, 08-035-0004**Figure 26. Chatfield Park View #1****Figure 26. Chatfield Park View #2****Location/Address:** 11500 N. Roxborough Road, Littleton Colorado 80125**Directions:** From 8699 North Daniels Park Road, Sedalia, Colorado 80135

- Take N Daniels Park Road, E Wildcat Reserve Parkway, US-85 S/Santa Fe Drive and W Titan Road to Roxborough Park Road for 13.9 miles
- Arrive at 11500 N Roxborough Park Road, Littleton, Colorado 80125

**Note 1:** Location is approximately 10.27 miles south of Denver, Colorado**Note 2:** Location is 27.656 miles from Aurora East/DU-ARTI**Note\*\*:** This site was a spiral overflight location for the DISCOVER-AQ aircraft.**Latitude:** 39.534488 (39°32'04.1568")**Longitude:** -105.070358 (-105°04'13.2888")**Altitude:** 5498 ft (1675.79 m)**Site Contact:** 303-791-7275

Equipment	Power Req	Dimensions	Number of Units	Comments
Photolytic NO <sub>2</sub>	100 – 120V, 220 – 240V, 50-60Hz	N/A	1	
O <sub>3</sub> Monitor	N/A	N/A	1	
Aeronet	N/A	N/A	1	
T700 U Calibrator	85V-264V, 47 – 63 Hz			
701H ZAG	115V, 60Hz			
Pandora	N/A	N/A	1	
Wind Speed, Wind Direction, Temperature	N/A	N/A	1	

**Site 24: Welch****Owner:** CDPHE**Description:** CDPHE, 08-059-0005**Figure 27. Welch View #1****Location/Address:** 12500 W. Quincy Avenue, Morrison Colorado 80465**Directions:** From 11500 N Roxborough Road, Littleton, Colorado 80125

- Take Chatfield State Park to CO-121 N/S Wadsworth Boulevard in Jefferson County for 4.9 miles
- Take CO-470 W to West Quincy Avenue. In 8.9 miles, take the Quincy Avenue exit from CO-470 W
- Drive to W Quincy Avenue in 1.2 miles
- Arrive at Welch, 12500 W Quincy Avenue, Morrison, Colorado 80465

**Note 1:** Location is 19.04 miles from Squaw Mountain**Note\*\*:** This site was an overflight location for the DISCOVER-AQ aircraft.**Latitude:** 39.638780 (39°38'19.6080")**Longitude:** -105.139510 (-105°08'22.2360")**Altitude:** 5719 ft (1743.151 m)**Site Contact:** Garry Kaufman (Air Quality Division Deputy Director): 303-692-3269; Lisa Devore (Air Quality Issues): 303-692-3117

Equipment	Power Req	Dimensions	Number of Units	Comments
O <sub>3</sub> Monitor	N/A	N/A	1	
Wind Speed, Wind Direction, Temperature	N/A	N/A	1	

**Site 25: Aurora East****Owner:** CDPHE**Description:** CDPHE, 08-005-0006

Figure 28. Aurora East View #1

Figure 28. Aurora East View #2

**Location/Address:** 36001 East Quincy Avenue, Watkins Colorado 80137**Directions:** From 12500 W Quincy Avenue, Morrison, Colorado 80465

- Get on CO-470 E in 1.8 miles
- Follow CO-470 E and E-470 N to E Quincy Avenue in Arapahoe County. In 33.0 miles, take exit 13 from E-470 N
- Drive to Airline Road/E Quincy Avenue in 5.1 miles
- Arrive at Aurora East, 36001 E Quincy Avenue, Watkins, Colorado 80137

**Note 1:** Location is approximately 11 miles east of Denver, Colorado**Note 2:** Location is 30.366 miles from Welch**Latitude:** 39.638540 (39°38'18.7440")**Longitude:** -104.569130 (-104°34'08.8680")**Altitude:** 5912 ft (1801.978 m)**Site Contact:** Garry Kaufman (Air Quality Division Deputy Director): 303-692-3269; Lisa Devore (Air Quality Issues): 303-692-3117

Equipment	Power Req	Dimensions	Number of Units	Comments
Aeronet	N/A	N/A	1	
O <sub>3</sub> Monitor	N/A	N/A	1	
Wind Speed, Wind Direction, Temperature	N/A	N/A	1	

**Site 26: Denver-LaCasa (NCORE)****Owner:** CDPHE**Description:** CDPHE, 08-031-0026

Figure 29. Denver-LaCasa (NCORE) View #1

Figure 29. Denver-LaCasa (NCORE) View #2

**Location/Address:** 4545 (4587) Navajo Street Denver Colorado 80207**Directions:** From 36001 E Quincy Avenue, Watkins, Colorado 80137

- In 8.0 miles, get on I-70 W, in Adams County
- Follow I-70 W to Pecos Street in Denver. In 21.9 miles, take exit 273 from I-70 W
- Continue on Pecos Street. Drive to Navajo Street in 0.5 miles
- Arrive at Denver-LaCasa (NCORE), 4545 Navajo Street, Denver Colorado 80211

**Note 1:** Location is 40.332 miles from Mines Peak**Note\*\*:** This site was a spiral overflight location for the DISCOVER-AQ aircraft.**Latitude:** 39.779490 (39°46'46.1640")**Longitude:** -105.005180 (-105°00'18.6480")**Altitude:** 5254 ft (1601.419 m)**Site Contact:** 303-436-8770

Equipment	Power Requirements	Dimensions	Number of Units	Comments
PE Airbase	12 V Adapter	26 x 17 x 7 cm	2	Small air pollution sensor: (EPA evaluation activity)
Aeroqual O <sub>3</sub>	12 V Adapter	195 x 122 x 54 mm	1	Small air pollution sensor: (EPA evaluation activity)
Aeroqual NO <sub>2</sub> /RH/T	12 V Adapter	195 x 122 x 54 mm	1	Small air pollution sensor: (EPA evaluation activity)
AQMesh	Lithium ion battery	4.6 x 7.0 x 5.5 in	2	Small air pollution sensor: (EPA evaluation activity)
CAPS NO <sub>2</sub>	80W, 100 – 250VAC, 50 – 60Hz	N/A	1	
O <sub>3</sub> Monitor	N/A	N/A	1	
NO <sub>x</sub> /NO <sub>y</sub>	N/A	N/A	1	
SO <sub>2</sub>	N/A	N/A	1	
PM <sub>2.5</sub>	N/A	N/A	1	
PM <sub>10</sub>	N/A	N/A	1	
NO <sub>2</sub>	N/A	N/A	1	
Pandora	N/A	N/A	1	
Aeronet	N/A	N/A	1	

**Site 27: Denver I-25**  
**Owner: CDPHE/EPA**  
**Description: 971 Yuma St.**

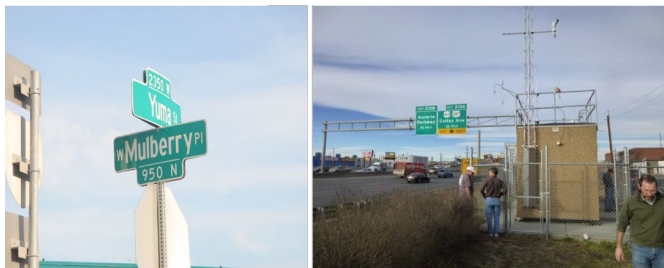


Figure 30. Denver I-25 View #1 Figure 30. Denver I-25 View #2

**Location/Address:** 971 Yuma Street, Denver Colorado 80204

**Directions:** From 4545 Navajo Street, Denver, Colorado 80211

- Head north on Navajo Street toward W 46th Avenue
- Take Pecos Street to Osage Street. Follow for 0.9 miles
- Turn right onto Osage Street
- Take I-25 S and Zuni Street to Yuma Street for 3.6 miles
- Arrive at 971 Yuma Street, Denver, Colorado 80204

**Note 1:** Sensors, near-road NO<sub>2</sub> monitor (location near Highway 6/Grand Army of the Republic Highway/I-70)

**Note 2:** Location is 10.133 miles from NREL-Golden

**Latitude:** 39.732146 (39°43'55.7256")

**Longitude:** -105.015317 (-105°00'55.1412")

**Altitude:** 5207 ft (1587.094 m)

**Site Contact:** Garry Kaufman (Air Quality Division Deputy Director): 303-692-3269; Lisa Devore (Air Quality Issues): 303-692-3117

Equipment	Power Requirements	Dimensions	Number of Units	Comments
Cairclip NO <sub>2</sub>	Solar power	32 x 62 mm	1	Small air pollution sensor: (EPA evaluation activity)
Cairclip NO <sub>2</sub> /O <sub>3</sub>	Solar power	32 x 62 mm	1	Small air pollution sensor: (EPA evaluation activity)
AQMesh	Lithium ion battery	4.6 x 7.0 x 5.5 in	1	Small air pollution sensor: (EPA evaluation activity)
CAPS NO <sub>2</sub>	80W, 100 – 250VAC, 50 – 60Hz	N/A	1	
NO <sub>2</sub>	N/A	N/A	1	
Pandora	N/A	N/A	1	

**Site 28: Welby**  
**Owner: CDPHE**  
**Description: CDPHE, 08-001-3001**

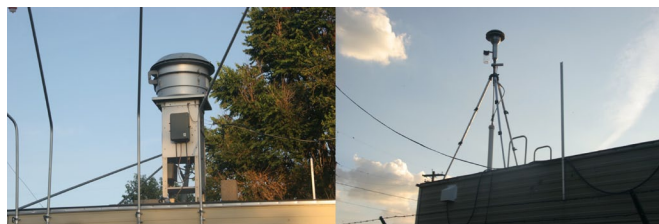


Figure 31. Welby View #1

Figure 31. Welby View #2

**Location/Address:** 3174 E. 78<sup>th</sup> Avenue (78<sup>th</sup> Avenue and Steele Street), Denver Colorado 80229

**Directions:** From 971 Yuma Street, Denver, Colorado 80204

- Head west on Yuma Street toward W Mulberry Place
- Continue on I-25 N to Welby. In 7.1 miles take exit 216A from I-25 N
- Continue on E 70th Avenue for 2.4 miles. Drive to E 78th Avenue
- Arrive at Welby, 3174 E 78th Avenue, Denver, Colorado 80229

**Note 1:** Location is 29.151 miles from Fritz Peak

**Latitude:** 39.838200 (39°50'17.5200")

**Longitude:** -104.949845 (-104°56'59.4420")

**Altitude:** 5105 ft (1556.004 m)

**Site Contact:** Garry Kaufman (Air Quality Division Deputy Director): 303-692-3269; Lisa Devore (Air Quality Issues): 303-692-3117

Equipment	Power Requirements	Dimensions	Number of Units	Comments
O <sub>3</sub> Monitor	N/A	N/A	1	
NO <sub>x</sub> /NO <sub>y</sub>	N/A	N/A	1	
SO <sub>2</sub>	N/A	N/A	1	
PM <sub>10</sub>	N/A	N/A	1	

Wind Speed, Wind Direction, Temperature

N/A N/A 1





# APPENDIX E

During the DISCOVER-AQ field study, EPA used the opportunity to continue its evaluation of small, emerging technology, air pollution sensors from a number of manufacturers. These sensors were located with the standard Federal Reference Method (FRM) and Federal Equivalent Method (FEM) air pollution monitoring systems at the following four DISCOVER-AQ sites in and around the Denver area: NREL-Golden, BAO Tower, Denver-LaCasa, and Denver I-25 (Near-Roadway site). Co-locating the air pollution sensors with the standard air pollution measurement systems facilitates assessment of the sensors as compared to FRM and FEM systems used to determine compliance with the NAAQS for the six criteria air pollutants (Lead [Pb], Carbon Monoxide [CO], Sulfur Dioxide [SO<sub>2</sub>], Nitrogen Dioxide [NO<sub>2</sub>], Ozone [O<sub>3</sub>], Particulate Matter [PM]). There were three additional ‘citizen science’ sites where EPA placed air pollution sensors to allow citizen participation and increase awareness of air pollution levels in their locations. The citizen science air pollution sensor sites were located in the following three places: Colorado School of Mines (Golden CO), a private residence (Golden CO), and the EPA Region 8 Building (Denver CO). The equipment configuration for each site is provided below.

## Site A. Colorado School of Mines (Golden CO) – Location: Library Rooftop

Equipment	Power Requirements	Dimensions	Number of Units	Comments
Cairclip NO <sub>2</sub>	Solar power	32 x 62 mm	1	Small air pollution sensor: (EPA evaluation activity)
Cairclip NO <sub>2</sub> /O <sub>3</sub>	Solar power	32 x 62 mm	1	Small air pollution sensor: (EPA evaluation activity)
AQMesh	Lithium ion battery	4.6 x 7.0 x 5.5 in	1	Small air pollution sensor: (EPA evaluation activity)

## Site B. Private Residence (Golden CO)

Equipment	Power Requirements	Dimensions	Number of Units	Comments
Cairclip NO <sub>2</sub> /O <sub>3</sub>	Solar power	32 x 62 mm	1	Small air pollution sensor: (EPA evaluation activity)
AQMesh	Lithium ion battery	4.6 x 7.0 x 5.5 in	1	Small air pollution sensor: (EPA evaluation activity)

## Site C. EPA Region 8 Building (Denver CO) – Location: Rooftop

Equipment	Power Requirements	Dimensions	Number of Units	Comments
Cairclip NO <sub>2</sub>	Solar power	32 x 62 mm	1	Small air pollution sensor: (EPA evaluation activity)
Cairclip NO <sub>2</sub> /O <sub>3</sub>	Solar power	32 x 62 mm	1	Small air pollution sensor: (EPA evaluation activity)



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