Mobile Air Toxics Monitoring for Assessing Community Exposure near Refineries and Industries in Davis County, Utah

Applicant:	Utah Division of Air Quality P.O. Box 144820 Salt Lake City, Utah 84114-4820
Contact Person:	Nancy Daher, Ph.D. Environmental Scientist 801-536-4078 Fax: 801-536-4099 ndaher@utah.gov
Category:	Community-scale monitoring
Funding Requested:	$304,130
Total Project Cost:	$304,130
Project Period:	October 2017 – February 2020
DUNS number:	8260010590000

Basis and Rationale

The Bountiful-North Salt Lake-Woods Cross area in Davis County, Utah, has a large industrial sector with a landfill, several oil refineries, metal processing, painting/coating manufacturing and electricity generation facilities (figure 1). Several roadways, railroads and highways also run through this area, in which regulated emission sources and smaller unregulated sources are found dispersed among a mosaic of residential areas rep resenting a significant range of socio-economic conditions. Given their close proximity to and mostly downwind location from these sources, communities in this area are susceptible to high air toxics emissions, including volatile organic compounds (VOCs).

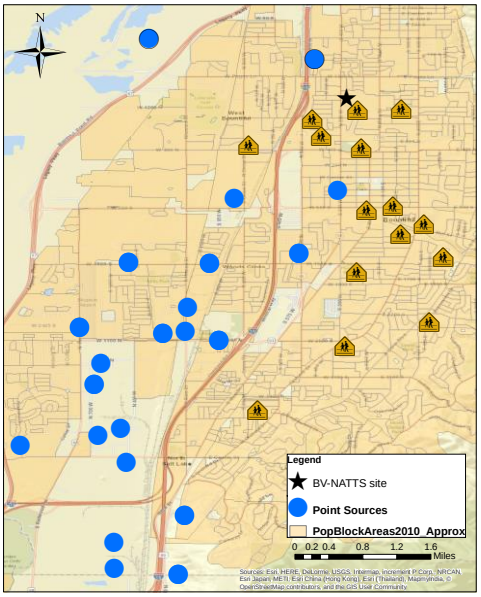

Figure 1. Map of the Bountiful-North Salt Lake- Woods Cross area, with focus on populated areas (data retrieved from https://gis.utah.gov/data/demographic/2010-census-data/). Schools and major industrial sources are also shown on the map.

In 2015, a year-long air toxics study conducted by the Utah Division of Air Quality (UDAQ) at three fixed sites along Utah's Wasatch Front showed an increase in 24-hr average concentrations of methylene chloride compared with previous years at Bountiful Viewmont (BV) site, which is a National Air Toxics Trends Station (NATTS) in Davis County[1]. Levels of methylene chloride were also generally highest at the BV-NATTS site compared to less industrialized West Valley and Lindon stations located further south in Salt Lake and Utah Counties, respectively. Moreover, concentrations of methylene chloride often exceeded its corresponding cancer risk screening value with over 50% of the measurements being associated with a cancer risk greater than one-in-a-million (table 1). Of the 120 sampling days, the study identified seven events when the ambient methylene chloride concentrations were one to two orders of magnitude above the cancer screening value. Benzene was also present in appreciable levels, with concentrations often exceeding the one-in-a-million cancer

[1] Utah Division of Air Quality, 2015 Special Toxics Study Report. https://deq.utah.gov/Pollutants/H/haps/docs/2015-Special-Toxics-Study.pdf

risk threshold (table 1). Moreover, preliminary findings from a recent air toxics monitoring saturation study, where five-day time-integrated passive samples were collected at 34 community-based sampling sites throughout Davis County during winter, showed higher methylene chloride levels close to a landfill in Bountiful. Levels of benzene, toluene, ethylbenzene and xylenes (BTEX) were also elevated close to one of the refineries in the sampling area. However, while these studies helped identify high-concentration and high-risk VOCs, they did not provide sufficient information on their source/sources and temporal variation. Measurements were limited to extended sampling periods (24-hr or 5 days), limited sampling frequency (1-in-3 days) and spatial coverage, as well as the collection of time-integrated samples (canisters and passive samplers) followed by offline laboratory analysis. This can lead to exposure misclassification. To identify the sources of these critical air toxics and determine their spatio-temporal variation and associated health risks, UDAQ is proposing to conduct a mobile air toxics monitoring campaign in the Bountiful-North Salt Lake-Woods Cross area. This work will complement findings from UDAQ previous studies and NATTS historical measurements at the BV-NATTS site.

The main objective of the proposed mobile air toxics monitoring campaign is to obtain high temporally- and spatially-resolved measurements of VOCs, and to identify their likely sources and associated health risks. This will help UDAQ better characterize risks from toxic VOCs within the Bountiful-North Salt Lake-Woods Cross communities and prioritize reduction strategies, in support of EPA's 2014-2018 Strategic Plan Goal 1, "Addressing Climate Change and Improving Air Quality". The proposed study supports category 1 "Community-Scale Monitoring" of this funding opportunity.

Table 1. Arithmetic mean and median methylene chloride and benzene concentration (ppbv), and associated one-in-one-million cancer screening value (ppbv) during 2013-2015. Data retrieved from UDAQ 2015 air toxics monitoring campaign and NATTS measurements.

Compound	Mean concentration (ppbv)	Median concentration (ppbv)	One-in-one-million cancer risk screening value (ppbv)
Methylene chloride	54.6	1.65	0.6
Benzene	0.28	0.23	0.09

Technical Approach

Objectives

The primary goal of this study is to measure ambient Hazardous Air Pollutant (HAP) concentrations and to assess community exposure near refineries and industries in the Bountiful-North Salt Lake-Woods Cross area. In order to achieve this goal, UDAQ is proposing to deploy a mobile monitoring platform. The mobile sampling trailer will be equipped with instruments for measurement of speciated VOCs, other co-pollutants (CO, NOx, ozone, $PM_{2.5}$, black carbon (BC), brown carbon (BrC) and particle number concentration) and meteorological parameters.

The overall objectives of the proposed study are to:

- Characterize the spatio-temporal variation of VOCs, mainly methylene chloride and BTEX, within the Bountiful-North Salt Lake-Woods Cross community.
- Identify major sources of VOCs emissions and assess their impact on surrounding communities.
- Assess the health risks associated with exposure to VOCs

A detailed sampling monitoring plan that will help address these objectives is discussed below.

Monitoring Plan

A mobile monitoring platform will be deployed to measure the spatio-temporal variation in VOC concentrations in the Bountiful-North Salt Lake-Woods Cross area. To determine the effect of atmospheric conditions on VOCs formation and levels, the mobile trailer will be deployed for approximately 6 weeks during each of the summer and winter seasons. Measurements will be taken at fixed locations throughout the sampling area during each season. At each location, sampling will be

conducted for several consecutive days, including weekdays and weekends. Continuous 24-hr measurements will also be taken, whenever possible. The project's investigators are in the process of locating secure sampling locations. Potential sampling sites are shown in figure 2. They can be classified as near-roadway, residential, mixed residential/light industrial, petrochemical industrial, heavy industrial and near-landfill. A detailed description of the sites characteristics is provided in table 2.

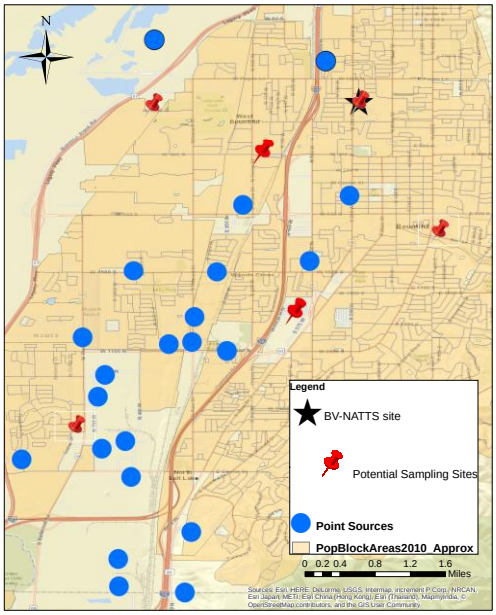

Figure 2. Location of potential sampling sites and nearby major industrial sources.

An existing 14'x7' trailer, equipped with electrical outlets and a roof-mounted HVAC system, will be configured to function as a mobile platform. The trailer, which includes a forward platform, will be towed to select monitoring locations. A propane-powered generator will also be installed to provide auxiliary electrical power and sampling inlet probes for particulate and gaseous instruments will be added. The trailer will house several instruments, including an automated gas chromatograph (GC) with dual detectors (flame ionization detection (FID) and electron captor detection (ECD)), a meteorological sensor as well as a CO, an ozone, a NOx, a continuous $PM_{2.5}$ and a BC/BrC analyzer. The BC/Br analyzer can provide an indication of the relative contributions of biomass burning compared to other combustion sources, like diesel engines. Two different columns will be used with the GC system to enable the measurement of a large suite of VOCs, including aromatic hydrocarbons and chlorinated compounds, such as BTEX and methylene chloride.

Table 2. Sampling sites characteristics.

Sampling site	Location	Type
West Bountiful Elementary School	0.28 mi north of a petroleum refinery; 1.6-3.8 mi north/northeast of several other industries and refineries	Petrochemical industrial
Woods Cross High School	0.10 mi east of I-15 interstate highway	Near-roadway
Bountiful Viewmont High School (current NATTS site)	0.45 mi southeast of a manufacturer of industrial gases and chemicals; within 0.25 mi from I-15 interstate highway and 5 mi from oil refineries as well as metal processing, painting/coating manufacturing and electric generation facilities	Mixed residential/light industrial
Bountiful High School	within 1.3 mi from I-15 interstate highway and 4 mi from oil refineries as well as metal processing, painting/coating manufacturing and electricity generation facilities	Residential
Wasatch Peak Academy	within 0.70 mi of manufacturing companies; 0.7 and 1.59 mi northwest and southwest of petroleum refineries, respectively	Heavy industrial
Fenceline	within 0.1 mi of Bountiful City landfill	Near-landfill

Time-integrated VOC samples will also be collected using a canister-based air toxics sampler (ATEC 2200), running in co-location with the GC-FID/ECD. Compositions obtained using both instruments will be compared to validate the in-field GC-FID/ECD results. A list of measured parameters, sampling frequency and sampling instruments is provided in table 3. All instruments, including the GC-FID/ECD system, will be calibrated before the start of each campaign. The GC-FID/ECD system's

operation will also be periodically checked throughout the sampling campaign using standard gases. The mobile platform will first be tested before deployment to the field by taking measurements at one of UDAQ's stationary monitoring stations. This will involve checking the electrical power system, operation of the generator and sampling instruments. For validation purposes, the mobile trailer measurements will also be compared to those taken at the stationary site, when available.

Table 3. List of measured parameters, sampling frequency and sampling instruments.

	Measured parameters	Sampling frequency	Instrument
Continuous	A suite of speciated hydrocarbons, including aromatic VOCs: benzene, toluene, ethylbenzene, xylene isomers, and chlorinated compounds: methylene chloride	2 hrs	Agilent 7890B Series GC with FID and ECD detectors as well as a Markes UNITY-xr AirServer with C-2-C14 cold trap*
	Ozone, NOx, CO	Hourly	Various instruments
	$PM_{2.5}$	Hourly	TEOM-1450 DF
	Black/brown carbon	Hourly	AE-33 Aethalometer
	Particle count	Hourly	GRIMM 1.109
	Temperature, relative humidity, pressure, wind speed and direction	Hourly	TBD**
Time-integrated	Speciated VOCs	12- or 24-hr	ATEC 2200 air toxics sampler

*Markes AirServer to be purchased; ** Equipment will be purchased

Data Analysis

The data will be evaluated in a multi-step process. A rigorous review of the data to evaluate its validity and reliability will first be completed. This includes screening the data for completeness, potential interferences, outliers and non-detects. Data validation and processing will then be followed by the following analyses:

- **Mobile Measurements and Mapping**

The spatial variation in VOCs concentrations will also be investigated. Figure 3 illustrates mobile measurements and mapping capabilities performed by Dr. Kelly's group. They collected GPS coordinates, $PM_{2.5}$ concentrations and brown carbon concentrations to investigate the geospatial variations in pollution contributions from wood burning. Mapping is performed with a Matlab code that generates an overlay for google maps. The proposed study will employ a similar approach to visualize the concentrations of selected VOCs.

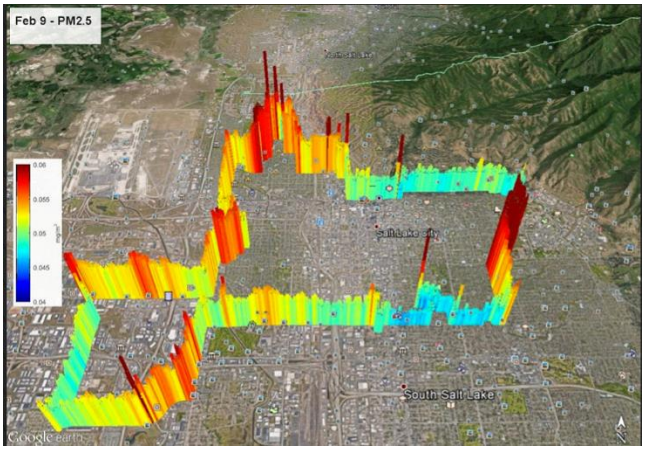

Figure 3. $PM_{2.5}$ concentrations (µg/m^3) during a cold-air pool on February 9, 2016, measured using a TSI 8350 DustTrak. Daily average $PM_{2.5}$ concentration at UDAQ Hawthorne monitoring station 50 µg/m^3.

- **Temporal Trends Analysis**

To assess exposure patterns and determine the atmospheric factors and sources controlling the HAPs concentrations, the day-of-week, diurnal and seasonal variability in speciated VOCs will be investigated. This involves visualizing the concentration of speciated VOCs by constructing time series and box plots using the high time-resolved GC-FID/ECD measurements. This also consists of conducting statistical analyses, which include generating summary statistics (mean, median, confidence intervals, standard deviation, etc.) and testing for statistical significance when comparing two concentrations (e.g. weekend vs. weekday).

- **Source Apportionment via PMF receptor modeling**

Major primary and secondary sources contributing to HAPs concentrations and their contributions will be determined using Positive Matrix Factorization (PMF) receptor model. UDAQ has extensive experience applying PMF for source apportionment modeling (N. Daher 2016, Hasheminassab et al. 2014a-b). PMF will be applied to the hourly gas-phase organic air toxics measurements, and species with sufficient data completeness and data above detection limit will be selected for this analysis. To aid in the source apportionment analysis, hourly gaseous (NOx, ozone, CO), particle (BC/BrC) and meteorological data will also be considered as input species to the PMF model. This analysis will also be complemented by wind field analyses to help determine potential source locations of the priority air toxics.

- **Exposure Assessment and Risk Characterization**

Based on the source apportionment results, gradients in exposure within the community surrounding the identified sources will be assessed. The associated inhalation cancer risks will also be calculated by estimating the average daily dose of the compounds of interest (using a 1-year averaging time) and combining that with cancer unit risk estimates (URE). This assumes that exposure during the portion of the year for which we have no exposure data is similar to that during the period for which we collected data. This assumption should be valid insofar as we are collecting data throughout the year. Additional use of these data includes investigation as to whether the BV-NATTS site is representative of other areas within the Bountiful-North Salt Lake-Woods Cross area, by quantifying exposure uniformity throughout the area. For this analysis, coefficients of divergence (COD) will be calculated between monitoring site pairs using site-average concentrations.

- **Apportionment of air toxics cancer risks to sources identified via PMF**

Source contributions to the inhalation cancer risks associated with the measured air toxics will be determined using the PMF results and additive cancer risks related to each PMF factor. Following an approach similar to the one described above, for a given pollutant, cancer risks will be estimated by multiplying the pollutant's URE by the fraction of its study-average concentration attributed to each PMF factor. The total cancer risk for each factor will then be calculated by adding the cancer risks of each pollutant apportioned to that factor. This analysis will provide insight on the relative contribution of emissions from different source classes to inhalation cancer risks due to the measured HAPs, which will help identify priority air toxics sources for risk reduction.

Environmental Justice Impacts

The proposed work will focus on specific communities in the Bountiful-North Salt Lake-Woods Cross area. These communities are located in close proximity to oil refineries as well as metal processing, painting/coating manufacturing and electricity generation facilities, making them susceptible to elevated air toxics emissions (figure 1). These communities are also potentially impacted by emissions from smaller unregulated facilities as well as nearby railroads, roadways and highways. A study recently conducted by UDAQ showed high levels of methylene chloride in Bountiful compared to other areas along Utah's Wasatch Front. This hazardous air pollutant was also generally associated with a high cancer risk, exceeding the one-in-a-million cancer risk threshold. Some communities in this area are at a higher cancer risk than 91% of the state's population, as indicated by the "National Scale Air Toxics Assessment

(NATA) air toxics cancer risk" (EPA Environmental Justice (EJ) mapping and screening tool, figure 4). Moreover, given Utah's unique topography and meteorology, these communities, which are located at low elevation in the Salt Lake Valley, are exposed to high levels of air toxics and $PM_{2.5}$ for longer duration during wintertime inversions compared to more affluent neighborhoods located at higher elevations (figure 5). Wintertime inversions commonly occur in this valley, leading to elevated air toxics and $PM_{2.5}$ levels, often exceeding the National Ambient Air Quality Standards. These socio-economic, environmental, meteorological and topographical factors create a disproportionately higher population exposure to air toxics in these communities compared to surrounding areas. The proposed work will help reduce the health effects and levels of air toxics in areas with highest priority environmental justice concerns. They will also help increase awareness on air pollution in underserved communities in Utah.

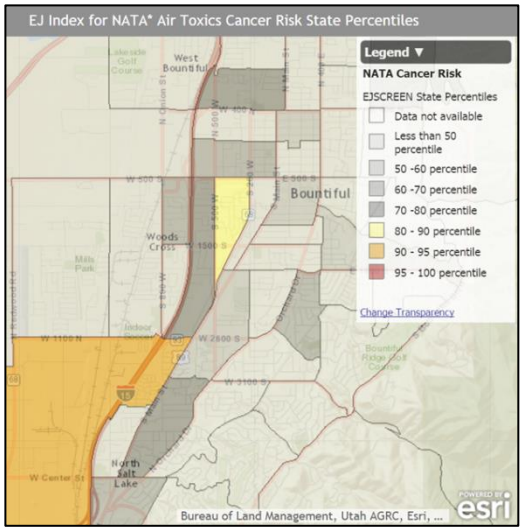

Figure 4. Environmental justice index for the "National Scale Air Toxics Assessment (NATA) air toxics cancer risk state percentile" in the Bountiful-North Salt Lake-Woods Cross area. Data retrieved from US EPA environmental justice mapping and screening tool.

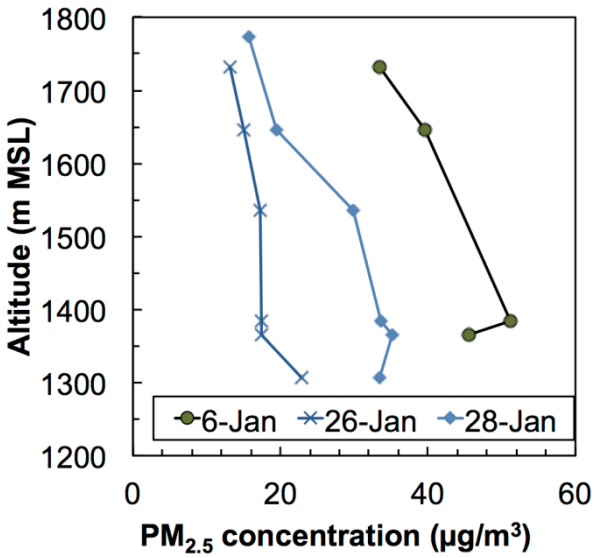

Figure 5. Difference in $PM_{2.5}$ concentration with elevation from Silcox et al. (2012).

Community Collaboration and Outreach

The project's investigators have a strong working relationship with the local businesses, community organizations, health professionals and educators in the sampling area. They will build on these relationships to increase awareness on air toxics pollution in Davis County. Specifically, the outreach effort will include:

- Engaging local business communities, including the Utah Petroleum Association, the refineries' community advisory panels (CAPs, four of the five refineries located in the study area have CAPs) and the Davis County Chamber of Commerce. These organizations are concerned with air quality in their communities and support science to better understand and address the region's air-quality challenges.
- The Davis County Health Department who will assist in securing sampling sites and organizing visits to local schools.
- Developing a teaching module and visiting local schools to engage students about air toxics and air quality in their community. These outreach efforts will build on the University of Utah Chemical Engineering Department's outreach program, which brings university-student ambassadors to over 50 classrooms and numerous science and engineering school events per year. The outreach team currently visits Woods Cross High School annually and periodically visits Bountiful High School. The school outreach efforts will also leverage Dr. Kelly's current AirU

citizen-science project (award: NSF 1642513) that is developing several hands-on teaching modules to help high-school and middle-school students understand air quality in the community. The AirU project is visiting 50 middle and high schools with low-cost PM sensors and teaching modules. For further distribution of the module and subject matter, the team will work with the Utah Educational Network, the Utah Association of Environmental Educators and the Davis County Health Department. The project's investigators will also contract with Breathe Utah to develop teaching modules and visit local grade and middle schools. Breathe Utah is a community air-quality advocacy 501(c)3 that works to improve Utah's air through education outreach, multi-stakeholder collaboration and policy change. The organization has an active education program for grades pre-K through 12 in which staff and volunteers visit schools with hands-on classroom activities. They visit 40-50 K-12 classrooms annually to teach students about health, science, politics and economics of the region's poor air quality. They have also been instrumental in implementing solutions to the region's air-quality challenges, such as retrofitting school buses to reduce their emissions.

All partners will also be periodically updated on the progress of the project through presentations and meetings. Letters from supporting entities are attached (community advisory panels for refineries, Utah Petroleum association, Davis school district and Davis County Health Department).

Environmental Results: Outcomes, Outputs and Performance Measures

Expected outputs and outcomes from this project are summarized in table 4.

Table 4. Expected outputs and outcomes (short-term, intermediate and long-term).

Outputs	**Outcomes**		
	Short-term	**Intermediate**	**Long-term**
High time-resolved and community-specific data Detailed mapping of VOCs concentrations in the Bountiful-North Salt Lake-Woods Cross area Identification of sources of high-risk VOCs, namely methylene chloride Publicly-available data Progress/final reports Presentations to refinery community council organizations and the Davis County Health Department (refer to support letters) Environmental educational module targeting school children	Increased community awareness Improved assessment of the impact of emissions from refineries/industries/roadways, small and/or unregulated sources on surrounding communities Improved understanding of short-term exposure to VOCs using state-of-the-art measurement techniques Identification of high-exposure communities	State/community action to mitigate HAPs	Reduction in emissions and ambient levels of HAPs Reduction in human exposure to HAPs

Performance Measures

The progress of the project will be evaluated following the below performance measures:

- Degree of sample data completeness and quality
- Timely execution of the proposed tasks (data collection and analysis)
- Timely submission of the proposed deliverables (reports, presentations, teaching module...)

- Degree of community engagement and involvement in the study
- Effective use of available resources
- Timely and efficient expenditure of funds

Timeline

Task	Year 1 Oct. 2017-Sept. 2018				Year 2 Oct. 2018-Sept. 2019				Year 3 Oct. 2019-Feb. 2020	
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
Equipment order										
Mobile route selection & mobile trailer setup/testing										
Instruments calibration										
Data collection & GC-FID/ECD system check										
Interim reports & update to community members										
Data validation & analysis										
Final report & outreach activities										

Programmatic Capability and Past Performance

UDAQ has a history of obtaining grants and successfully completing projects by meeting all grant requirements. UDAQ was awarded an EPA Exchange Network (EN) grant in October 2013 to upgrade and enhance the Utah Department of Environmental Quality Interactive Map (Grant # 83547601). UDAQ also received a second EN grant in October 2015 to build the GIS architecture for a tablet-based compliance tool (Grant # 83583601). Moreover, UDAQ was awarded an EPA Community-Scale Air Toxics Ambient Monitoring Grant in October 2015 to monitor both particle and gas phase organic HAPs in West Valley City, Utah (Grant # 96834601). UDAQ also recently completed the first phase of an air toxics saturation monitoring campaign in Davis County, Utah using funds provided through the US EPA Multipurpose Grant. The second phase of this study will be completed in summer 2017.

Key personnel (resumes attached)

Dr. Nancy Daher will oversee the progress of the project and fulfillment of the grant requirements. Dr. Daher is an environmental scientist at UDAQ and an adjunct professor at the University of Utah. She has a wide range of technical expertise, including ambient air quality monitoring and data analysis, such as applying receptor modeling techniques for source characterization of air pollutants. Dr. Daher led multiple field sampling activities, including a recent air toxics saturation monitoring campaign in Davis County. She also has extensive knowledge of the Bountiful-North Salt Lake-Woods Cross area and has established a strong working relationship with communities in this area.

Dr. Kerry Kelly will assist with the study design, lead the community outreach efforts, and assume responsibility for the GC, the real-time PM, and BC/BrC measurements, analysis and mapping. She is an Assistant Professor in Chemical Engineering. She has extensive experience with field sampling under challenging conditions including characterizing emissions from agricultural burns, F-18 aircraft, and military rocket firings. She and her students participated in US EPA Multipurpose Grant to collect and characterize the concentrations of HAPs in the Bountiful area. She is currently PI of the NSF citizen-science project AirU (award: 1642513) that is engaging local schools and community groups in measuring PM levels and understanding the reliability of low-cost sensors. She also serves on the State Air Quality Board as Vice Chair and on the Salt Lake City Air Quality Advisory Committee. Through her work on the Board and on numerous local air-quality projects, she has developed strong ties to local community groups, the business community and educators.

Dr. Darrah Sleeth will assist with the study design and analysis of exposure data. Dr. Sleeth is an Assistant Professor at the University of Utah, Rocky Mountain Center for Occupational and Environmental Health, with expertise in air sampling and exposure assessment. She has experience with field sampling in both environmental and occupational exposure studies as well as laboratory-based studies of sampler design and testing. She has investigated a variety of issues associated with air samplers and sampling design, including the effects of particle size, wind speed, sampling flow rate, sampler dimensions, sampler orientation, and particle charge. She has extensive experience with both real-time and integrated sampling methods as well as analysis of exposure data. She has collaborated widely with industry partners, community groups and government agencies.

Detailed Budget Narrative

Itemized costs associated with personnel wages, fringe benefits, travel, monitoring equipment, supplies, sub-contracts and indirect costs are listed in table 5. An existing 14'x7' sampling trailer will be configured for the mobile monitoring. The trailer, which is equipped with an HVAC system, an equipment rack and electrical outlets, will be retrofitted to include two propane gas cylinders, roof supports for installing a work deck, a front enclosure to house an electrical generator and a workbench. Electrical wiring and sampling inlet probes will also be installed.

Table 5. Detailed budget narrative.

Federal share, cost-share, and total project costs	**Federal**			**Cost-Share**			**Total**
PERSONNEL	**Estimated Hours**	**Hourly Rate**	**Cost**	**Estimated Hours**	**Hourly Rate**	**Cost**	**Total**
Scientist IV @ 30.8$/hr x 16 hrs/week x 36 weeks	576.0	$30.8	$17,740.8				
Scientist III @ 28$/hr x 40 hrs/week x 12 weeks	480.0	$28.0	$13,440.0				
Scientist III @ 28$/hr x 30 hrs/week x 12 weeks	360.0	$28.0	$10,080.0				
Total Personnel Cost			**$41,260.8**				**$41,260.8**
FRINGE BENEFITS. Calculated based on Personnel costs and includes retirement, 401k, social security, medicare, workmans comp, unemplyment insurance, long term disability and temination additive	**Rate**	**Base Amount**	**Cost**	**Rate**	**Base Amount**	**Cost**	**Total**
Total Fringe Benefits Cost	55.00%	$41,260.8	**$22,693.4**				**$22,693.4**
TRAVEL	**Rate/mile**	**Total Miles**	**Cost**	**Rate/mile**	**Total Miles**	**Cost**	**Total**
In-State Travel:							
To/from Office from/to air monitoring center: 12 miles/roundtrip @ 0.38$/mi x 120 trips	$0.38	1440.0	$547.2				
To/from air monitoring center to sampling sites: 37 miles/roundtrip @ 0.38$/mi x 5 trips/week x 13 weeks	$0.38	2405.0	$913.9				
To outreach activities: 30 miles x 10 trips	$0.38	300.0	$114.0				
Out of State Travel							
Total Travel			**$1,575.1**				
EQUIPMENT	**Cost Per Unit**	**# of Units**	**Cost**	**Cost Per Unit**	**# of Units**	**Cost**	**Total**
Retrofitting of existing trailer for mobile sampling (addition of a workbench, partition wall, roof/work deck, electrical wiring and miscellaneous hardware, side ladder ...)	$5,000.0	1.0	$5,000.0				
Propane generator	$5,000.0	1.0	$5,000.0				
Total Equipment			**$10,000.0**				**$10,000.0**
SUPPLIES	**Cost Per Unit**	**# of Units**	**Cost**	**Cost Per Unit**	**# of Units**	**Cost**	**Total**
Miscellaneous supplies (sampling manifolds, fittings, fan blower/ozone scrubber for ATEC sample	$3,000.0	1.0	$3,000.0				
Laptop for datalogging	$2,000.0	1.0	$2,000.0				
Meteorological sensor. Includes mounting adapter, software, digital sensor interface, cable assembly and support tripod	$3,000.0	1.0	$3,000.0				
Propane gas tanks with mounts and controls, incldluing an automatic valve	$1,000.0	1.0	$1,000.0				
Propane gas refill	$2,000.0	1.0	$2,000.0				
Total Supplies			**$11,000.0**				**$11,000.0**
CONTRACTUAL	**Cost**			**Cost**			**Total**
Subcontract to Dr. Kerry Kelly, University of Utah for the operation of the GC/FID and analysis of the collected data. See attached "KerryKellyBudget" pdf	$128,346.0						
Subcontract to Dr. Darrah Sleeth, University of Utah for performing the exposure assessment and risk characterization analysis. See attached "DarrahSleethBudget" pdf	$45,215.53						
Subcontract to Breahe Utah for outreach activities. See attached BreatheUtah.pdf	$990.0						
TO-15 analysis with GC/MS. 66 samples (5/week x 6 weeks x 2 seasons + 10% duplicate). Cost/sample includes cost for analysis as well as canister, canister cleaning, handling and	**Cost/sample**	**# of samples**	**Cost**				
	$481.0	66.0	$31,746.0				
Total Contractual			**$206,297.5**				**$206,297.53**
CONSTRUCTION	**Cost Per Unit**	**# of Units**	**Cost**	**Cost Per Unit**	**# of Units**	**Cost**	**Total**
Total Construction			**$0.0**				**$0.0**
OTHER: rent, phones, LAN, building utilities, printing, etc.	**Base Amount**		**Cost**	**Base Amount**		**Cost**	**Total**
Phones, building/site rental, LAN, building utilities, printing/photocopying, outreach material	$3,276.87		$3,276.9				
Total Other			**$3,276.9**				**$3,276.9**
TOTAL DIRECT COSTS. Include Match Funds			**$296,103.7**				**$296,103.7**
TOTAL INDIRECT COSTS. Calculated based on OMB Circular A-87 Cognizant Agency Negotiation Agreement. Percentage taken from personnel and fringe benefits)	**Rate**	**Base Amount**	**Cost**	**Rate**	**Base Amount**	**Cost**	**Total**
Total indirect costs	**12.55%**	**$63,954.2**	**$8,026.3**				**$8,026.26**
TOTAL PROJECT COST			**Federal**			**Cost-share**	**Total (federal + cost-share)**
Total Cost			**$304,130.00**			**$0.00**	**$304,130.0**

Leveraging

Monitoring equipment provided by UDAQ and the University of Utah will be leveraged for this project, resulting in a total amount of $147,507 in leveraged funds for sampling equipment:

Table 6. List of leveraged equipment and associated funds.

Analyzer	Quantity	Leveraged cost ($)
CO	1	11,500
NOx	1	14,450
Ozone	1	7,332
Black/brown carbon	1	20,000
TEOM-1450DF	1	30,510
ATEC 2200	1	15,215
GRIMM 1.109	1	20,000
GC-FID	1	28,500
Total		**147,507**

Existing resources and technical expertise of the project's investigators will also be leveraged. UDAQ will configure an existing HVAC-equipped 14' x 7' sampling trailer for mobile monitoring and a UDAQ-owned vehicle will be used to tow the trailer. Dr. Kelly's group will also leverage their experience with developing spatial maps and educational modules as well as working with schools, local industry and community organizations. In addition, Dr. Kelly will leverage her Department's outreach teacher network and student-ambassador programs to assist with the outreach activities.

Expenditure of Awarded Grant Funds

The project's investigators will follow strict procedures and controls to ensure timely and efficient expenditure of funds. This includes:

- Selecting an analytical laboratory and vendors following a competitive bid process, in compliance with federal competitive procurement guidelines
- Setting up contracts that include specific tasks, timelines and fixed costs
- Detailed documentation and monthly review of the grant's expenditures by the project manager. This includes ensuring that only equipment and services necessary for the proposed project are purchased.
- Overseeing of sub-contracts and monitoring of expenditures by the finance/purchasing department at UDAQ. This involves monitoring the grant for compliance with all applicable federal, state and local regulations as well as ensuring that the grant expenditures are in compliance with grant procurement policies and procedures.