California Energy Commission
Technical Memorandum

Upper-Air Profiler Test Plan

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Prepared for California Energy Commission
Prepared by Sonoma Technology and Spatial Informatics Group, LLC

Primary Author(s):
Bryan Penfold and Tami Lavezzo
Sonoma Technology
1450 N. McDowell Blvd., Suite 200
Petaluma, CA 94954

Contract Number: EPC-18-026
Prepared for: California Energy Commission

Alex Horangic
Commission Agreement Manager

Laurie ten Hope
Deputy Director - Energy Research and Development Division

Drew Bohan
Executive Director

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Introduction

This technical memorandum contains a plan for siting, installing, and operating an upper-air wind profiler as part of the California Energy Commission (CEC) project *Comprehensive Open Source Development of Next Generation Wildfire Models for Grid Resiliency*. This work will be performed by Sonoma Technology, Inc. (STI) as part of the *Weather Station and Extreme Weather* working group, under *Task 3: Optimal Configuration of Weather Stations*. STI will deploy and operate an upper-air wind profiler to collect upper-air wind data in Northern California from July 1 to December 15, 2020. This is a pilot study to determine if upper-air measurements can be used to supplement surface observations, allowing utilities to anticipate the onset of strong winds.

Pilot Study Objectives and Approach

The objectives of the upper-air pilot study are to determine if upper-air wind data can be used by utilities to improve short-term (up to 15 hours) and very-short-term (from 0 to 3 hours) extreme wind forecasts, and enhance situational awareness during high-wind events. The project also aims to integrate the collected data into next-generation fire models and data management systems currently used by utilities for routine operations.

To meet these objectives, STI will leverage and augment existing meteorological networks with upper-air wind measurements, and provide data for use in meteorological models and other data management systems currently used by utilities. The main pilot study elements include

- Working with the *Weather Station and Extreme Weather* working group under *Task 3: Optimal Configuration of Weather Stations* to identify the optimal site location for an upper-air instrument in Northern California;
- Installing the upper-air profiler;
- Operating all instruments and performing periodic maintenance (if/when needed);
- Acquiring, monitoring, and quality controlling all data collected by the upper-air profiler;
- Delivering the data to project participants and utilities; and
- Developing a report that provides (1) the findings of the pilot study; (2) guidance on using upper-air profiler data to improve weather forecasts, enhance situational awareness, and augment existing utility data management systems; and (3) details on how to design, deploy, and maintain profiler networks.

This document provides a plan for conducting the upper-air wind pilot study.

Overview of the Upper-Air Profiler

STI will install and operate an Atmospheric Systems Corporation (ASC) Model 2000 Sodar at a location in Northern California (tentatively in or near Grass Valley). A Sodar (Figure 1) works by sending out a sound pulse and recording the sound as it is scattered off atmospheric turbulence back to the Sodar. After the sound pulse is transmitted, the Sodar records scattered sound to determine wind speed, direction, inflow angle, and height. The resulting data provide information about the atmospheric wind profile.

The Sodar 2000 uses three parabolic dishes with a compression driver at the focal point of each dish to generate audible acoustic pulses (i.e., chirps or beeps every 4 to 6 seconds). The parabolic dishes are situated so that two orthogonal horizontal wind components (u, v) and one vertical wind component (w) are sampled to compute the reported wind profile. A receiver measures the small amounts of the transmitted sound that are scattered back toward the sodar. These backscattered signals are received at a slightly different frequency than the transmitted signal. This difference is called the Doppler frequency shift and is directly related to the velocity of the air moving toward or away from the sodar along the direction the beam is pointing. The radial velocity measured by the tilted beams is the vector sum of the horizontal motion of the air toward or away from the sodar, plus any vertical motion present in the beam. Using trigonometry, the three-dimensional meteorological velocity components (u, v, w), wind speed, and wind direction are calculated from the radial velocities. The Sodar 2000 operates at a frequency of ~1,800 Hz and the emitted sound is ~90 dbA. Because they emit sound, the sodar will be located as far away from nearby residences as possible.

Figure 1. Photograph of a trailer-mounted Sodar 2000.

The data collected by the Sodar 2000 show wind speed and direction by time and vertical height. Figure 2 shows an example of data collected by the Sodar 2000. The hourly wind data will have a vertical resolution of approximately 20 m from about 80 to 600 m agl. The upper-air data will be collected on a continuous, hourly basis, and will be periodically reviewed by a trained data analyst to ensure that the instrument and data systems are functioning properly throughout the deployment period.

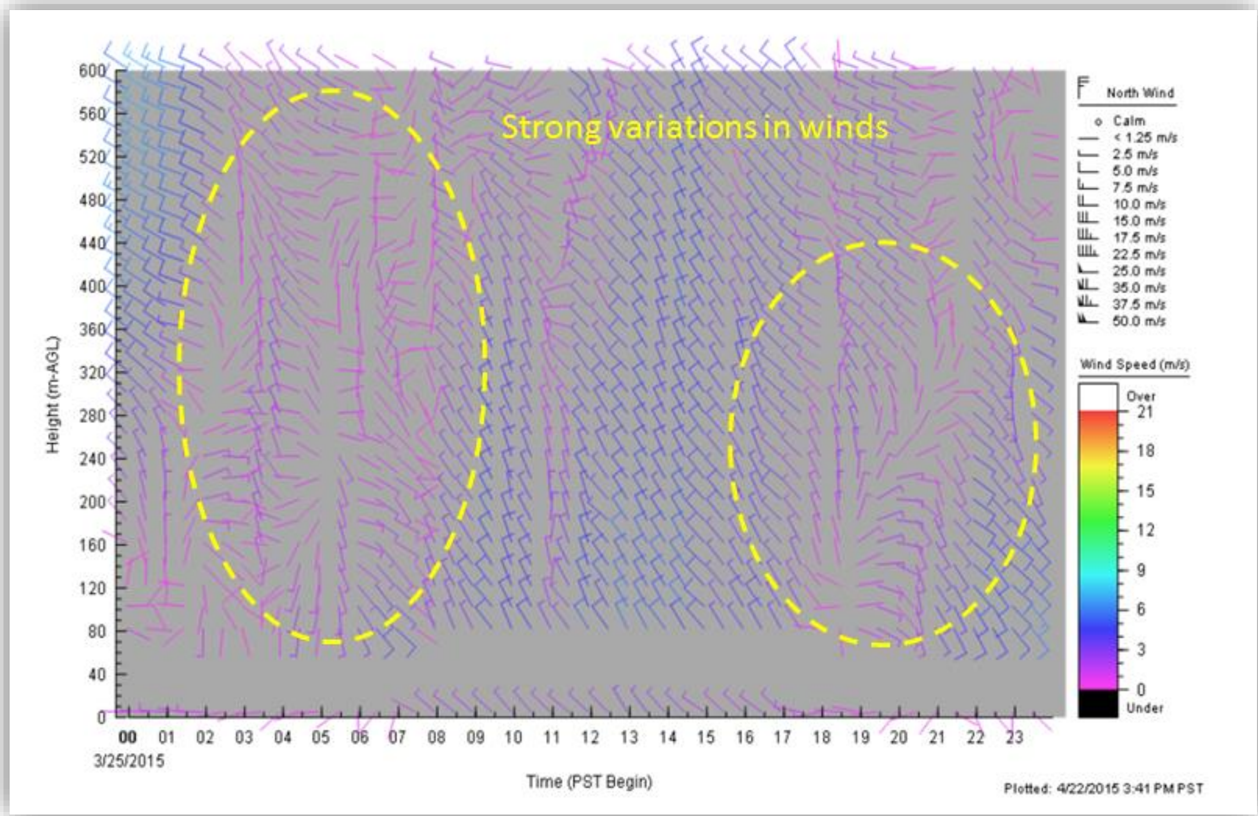

Figure 2. Example of data collected by the Sodar 2000 with strong variations in wind shown by time and height.

Rationale for Instrument Site Selection

Extreme wind events in Southern and Northern California, such as those present during Northern California's 2018 Camp Fire and 2017 Tubbs Fire, often damage power lines and can cause wildfires to spread rapidly. In Northern California, these winds are referred to as Diablo winds, and in Southern California they are referred to as Santa Ana winds. These winds occur as systems of high pressure form in the Great Basin and flow over the Sierra Nevada Mountains (from the east) toward the Pacific Ocean (to the west). As winds flow over the Sierra Nevada Mountains, they compress, warm, and lower the relative humidity while drying out vegetation. As the winds move through canyons, they pick up speed creating strong gusts (Figure 3). The Northern California Diablo winds are most common in the late summer through early winter. It is under these wind regimes that California typically experiences its largest and most destructive fires.

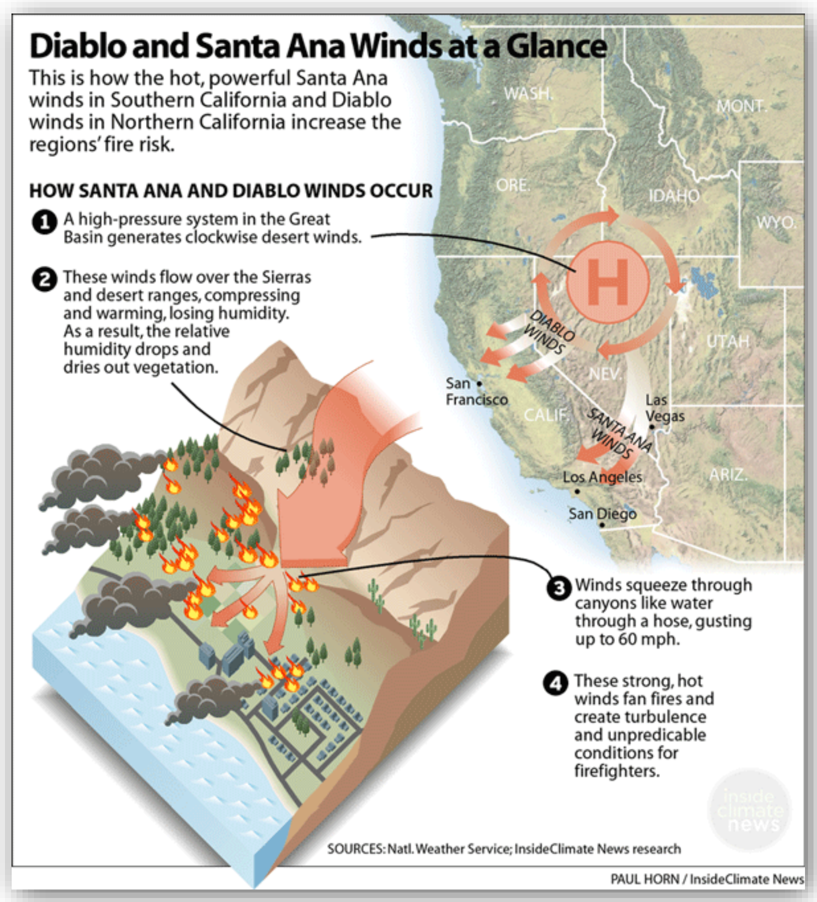

Figure 3. Illustration and explanation of the Diablo and Santa Ana winds. Source: National Weather Service, InsideClimate News research.

Historical weather data and preliminary burn probability analyses performed by the *Weather Station and Extreme Weather* working group indicate that the area in and around Grass Valley is a candidate site for an upper-air profiler for Northern California. This site will allow the profiler to capture upper-air winds as they move over the Sierra Nevada Mountains and down through the valleys.

The *Weather Station and Extreme Weather* working group (Working Group) will be performing analyses to determine the optimal configuration of weather stations as part of Task 3. The Working Group will develop a methodology for identifying the optimal location for future weather station sites to generate maximum information content about wildfire risks, especially from wind. This work will complement stations already installed or planned by the IOUs. The methodology will describe a computational method based on maximum entropy (MaxEnt) modeling (or a similar model approved by the CAM) to combine multiple layers of information to optimize weather station locations. The network of weather stations will be designed for wildfire situations with the potential to affect electrical assets, including transmission and distribution lines, substations, and power plants. Factors to be considered also include wind patterns, wildland fuels, access, and proximity of utility assets and other critical assets at risk. While we are currently targeting a location in or near Grass Valley, we will use the findings from the Task 3 analyses to further refine the site location for the upper-air profiler.

Because we do not know the exact site location for the upper-air profiler at this time, permits may be required to install the instrument. Whenever we deploy an upper-air profiler, we always favor existing sites with the power and infrastructure in place to accommodate the instrument (i.e., existing air quality monitoring stations, weather stations, or government properties with a flat surface and access to power). STI provided a letter to SIG, dated July 3, 2019, which outlines the permit requirements that may be required for the upper-air profiler. We have included the letter as **Attachment A** of this Technical Memorandum for reference.

We are in the process of exploring a potential opportunity to collocate the upper-air profiler with an existing utility-owned weather station or on utility-owned property. We have been attempting to reach Bereket Habtezion of PG&E to discuss this option and to identify PG&E property or facilities in and around the Grass Valley area that would be suitable for the upper-air profiler.

Instrument Preparation, Installation, and Operations

The objective of routine instrument operations is to ensure high-quality data and high data recovery rates. Operations for this project will be divided into two main elements: pre-deployment instrument interface and testing, and routine operations.

The Sodar 2000 currently resides at STI's offices in Petaluma, California. To prepare the Sodar 2000 for deployment, the power source, computer, data management system, and communications will be tested and verified at STI, and system corrections will be made as needed. Prior to deployment, STI's team will confirm that all systems, from data collection to data delivery and archiving, are working together properly. STI's team will install the Sodar 2000 at the field site in accordance with manufacturers' guidelines, and will field test the equipment to ensure that all components are working properly.

Maintenance of all instruments is critical to successful operations. STI's team will conduct routine monitoring of the Sodar 2000 operation and performance. If needed, STI's team will perform maintenance and make emergency site visits. If site visits are needed, STI staff will perform the following checks and maintenance

- Visually inspect the instrument and cables.
- Verify that the instrument is collecting reasonable data for the current weather conditions.
- Inspect the instrument base to ensure that it remains mounted.

- Verify the instrument orientation and level.
- Verify disk space on the instrument and data logger.
- Verify that the Sodar speakers are operating.
- Make instrument repairs when needed.

On a routine basis, meteorologists at STI's Weather Operations Center will compare the upper-air data collected by the Sodar 2000 with external data sources such as the North American Mesoscale Model (NAM) and the Global Forecast System (GFS) as a quality control measure. This will allow STI to identify any operational or equipment problems.

Data Flow and Processing

Reliable communications with field sites is a fundamental requirement to (1) ensure high data recovery rates, (2) monitor instrument performance, (3) remotely diagnose instrument problems, and (4) make instrument system changes as needed. Cellular communications and file transfer protocol (FTP) will be used to support instrument communications for this pilot study.

Dual-band cellular modems will be located at the site. STI will automatically push data from the Sodar 2000 to FTP servers every 30 minutes. Once the data are uploaded, automated processes will import the raw data to a Microsoft® SQL Server® database, effectively combining all data into a single data set. The raw data files will be stored and backed up each day. Another automatic process will generate images of the data and uploaded them to the project website. An example of the website used to monitor the data is shown in Figure 4.

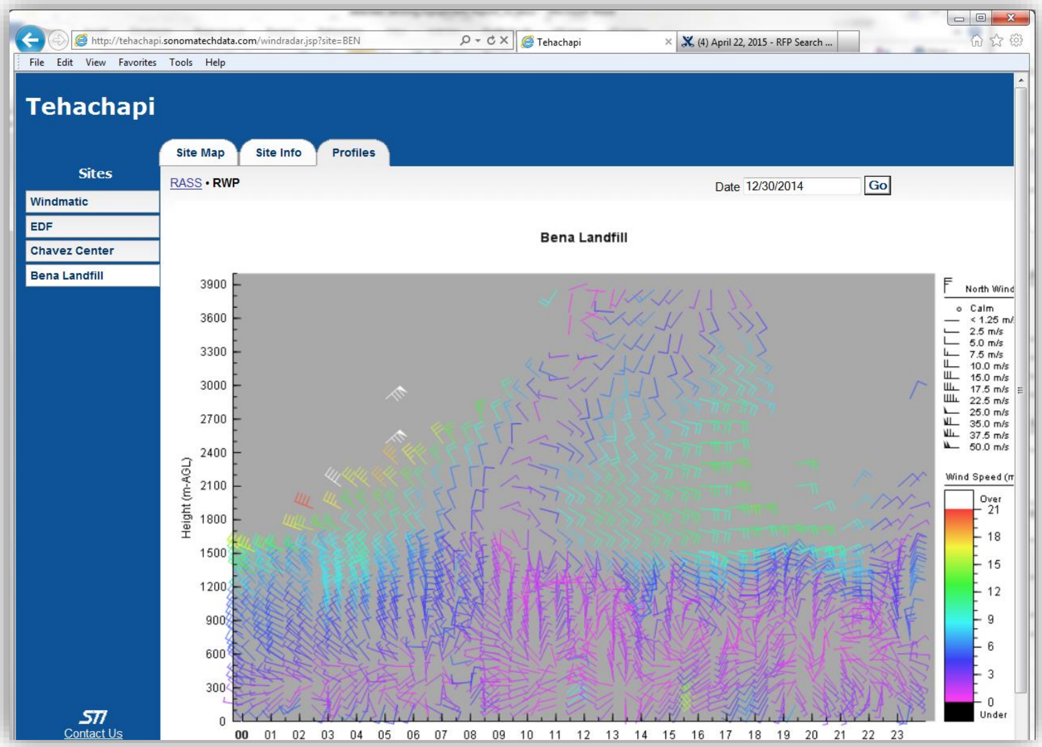

Figure 4. Example of the project website that will be used to monitor the data collected by the Sodar 2000 during the pilot study.

At the conclusion of the pilot study, STI will assemble and document the upper-air data and make it available in a format(s) compatible with weather and fire model applications. STI will collaborate with the Working Group members to use the upper-air data for model validation, forecast improvements, and situational awareness applications. As appropriate, STI will collaborate with utility operators to identify how upper-air data can be used to augment data systems and operational tools already in use by utilities. STI's final project deliverable will be a report that (1) summarizes the findings of the pilot study; (2) provides guidance on using upper-air profiler data to improve weather forecasts, enhance situational awareness, and augment existing utility data management systems; and (3) provides guidance on designing, deploying, and maintaining profiler networks.

Schedule

The schedule for conducting and completing the upper-air pilot study is shown in Table 1.

Table 1. Schedule for conducting and completing the upper-air pilot study.

Task/Activity	Task/Activity Duration	Target Due Date
Develop and deliver an Upper-Air Profiler Test Plan (this document)	1 week	9/30/2019
Identify upper-air profiler site location	1 month	1/31/2020
Prepare profiler site location for deployment (i.e., identify location; as needed – obtain permits, negotiate lease, prepare ground, install power)	3 months	5/15/2020
Prepare upper-air instrument and data systems for deployment	1 month	5/15/2020
Install and test upper-air instrument in the field	1 week	6/15/2020
Operate upper-air instrument	6 months	12/15/2020
Assemble, document, and deliver data	As needed	1/15/2021
Develop and deliver Upper-Air Profiler Report/Guidance Document	1 month	4/5/2021

Attachment A: Potential Permit Requirements for Siting the Upper-Air Profiler

July 3, 2019 STI-718117

Shane Romsos
Spatial Informatics Group (SIG)
2529 Yolanda Ct.
Pleasanton, CA 94566

Re: Potential permit requirements for siting the upper-air profiler

Dear Shane,

As per your request, this document summarizes the potential permit requirements for siting an upper-air profiler within the state of California; as part of the project entitled *"Comprehensive open source development of next generation wildfire models for grid resiliency" (*the project*)*. Under Task 2 (Working Group 1) of the project, STI will install and operate an upper-air wind profiler for several months. The goal of the pilot deployment is to provide guidance to IOUs on: 1) leveraging upper-air profiler data to improve weather forecasts and enhance situational awareness preceding and during high-wind events; 2) designing, deploying, and maintaining profiler networks; 3) designing robust data management systems to leverage those data.

Prior to determining the site location for the upper-air profiler, the project team will develop an *Extreme Weather Historical Pre-analysis Dataset* of historical weather data for major fire events. We will use the extreme weather dataset combined with the existing weather station network to identify potential siting locations for the upper-air profiler. Because we do not know the exact location of the upper-air profiler at this time, this document provides a discussion of the potential permit requirements for siting the instrument. Whenever we deploy an upper-air profiler, we always favor existing sites with the power and infrastructure in place to accommodate the instrument (i.e., existing air quality monitoring stations or government properties with a flat surface and access to power). If appropriate and feasible, we will explore the opportunity to collocate the upper-air profiler with an existing utility-owned weather station.

In the instance that permit(s) will be required to site the upper-air profiler, several siting factors will be considered before installing the instrument. The following outlines the potential permit needs based on siting factors.

- Deploying upper-air wind profiler (and ancillary equipment) on different types of land ownership (i.e., federal, state, private)
    - In most cases, site access is determined through a site access agreement with the land owner. STI will work with the project team and landowner to develop a site access agreement. It should be noted that past deployments of the upper-air profiler have been exempt from California Environmental Quality Act (CEQA) requirements.
- Electrical power requirements for the equipment
    - Electrical power is the most critical component for deployment, as the upper-air profiler and ancillary equipment needs a continuous power supply that is unachievable from an alternative power source (e.g., solar panel array). STI's primary option will be to leverage existing monitoring sites (air quality, meteorological, etc.) where grid-based electrical power and meters are accessible. For this case, STI and the project team will work with the appropriate agency to develop an accessibility agreement. If existing monitoring sites are unavailable, STI will need to identity a suitable area near grid-based electrical power. In both cases, local electrical permits will be required to install an electrical meter box from grid-based electrical power in order to supply power to our equipment. STI will work with a local, licensed electrical company to obtain permits and conduct the work.
- Additional infrastructure needs (i.e., terrain grading, foundation work)
    - The upper-air profiler and ancillary equipment require a flat and stable ground surface for operation. In several cases, STI has uses gravel as a foundation to address minor inconsistencies in ground level and natural drainage. Historically, applying a gravel base has not required city or county permits. If the selected site requires a more stable foundation to support the equipment, a concrete pad installation may be required. Permits associated with pouring a concrete pad are dependent on the municipality and land ownership. As part of the development of the upper-air profiler test plan (Task 2 deliverable), STI will focus on areas that can support the equipment in its natural state, thus avoiding permits associated with installing a concrete pad.

Our target upper-air profiler deployment timeframe is June 2020. Beginning in late winter to early spring, we will determine a location for the upper-air profiler. Site access agreements and permits will be acquired by late spring 2020 and a Permit Status Letter will be provided to the project team and CEC.

Please don’t hesitate to contact me at 707.665.9900 or tami@sonomatech.com. We look forward to working with you on this project.

Sincerely,

Tami Lavezzo
Vice President
Senior Scientist