I-68

Fog Detection System

Planning Report

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Table of Contents

Introduction 3
Big Savage Accident 3
Fog Background 5
Project objective 5
Report Outline 5

Fog Detection Background 7
Similar Projects 7
- St. Albans West Virginia 7
- Mobile, Alabama 7
- Fancy Gap, Virginia 7
- I-75 Fog Detection/Warning System 8
- Similar Project Summary 8

Technology 9
- Air Temperature & Relative Humidity 10
- Wind Speed & Direction 10
- Precipitation 10
- Visibility 10

Site Investigation 11
Fog Hazard Area(s) 11
- Big Savage 11
- Keysers Ridge 14
- Friendsville 15

Recommended System 18
Equipment Description 18
- RWIS 18
- Solar Power System 18
- Warning Sign 20
- Spread-spectrum Radio 20

Operation Description 21
Site-specific Components and Costs 21
- Big Savage 21
- Keysers Ridge 22
- Friendsville 23

Introduction

Reduced visibility caused by adverse and changing weather conditions can result in particularly severe traffic accidents involving many vehicles and injuries. Although not the only cause of reduced visibility, one of the most common is fog. Fog can reduce visibility to a few feet or even zero feet under certain conditions.

This situation existed on I-68 near Big Savage Mountain in May 2003. A serious multi-vehicle accident, the latest in a series of accidents caused by reduced visibility in fog, was the impetus for this investigation into remedial measures can be applied in this fog-prone corridor. The corridor in question extends along I-68 from the West Virginia state line to the vicinity of Frostburg, Maryland, a distance of approximately 35 miles as shown on Figure 1.

Figure 1. I-68 Corridor.

This Introduction section describes the accident that instigated this project. It then provides a brief meteorological background of the conditions that cause fog, and concludes with a statement of the objectives of the project and an outline of the report.

Big Savage Accident

On May 23, 2003, a multi-vehicle accident was reported on Interstate 68 at mile post 29, eastbound. When Fire and Rescue Units arrived, they found several vehicles involved in the eastbound accident. Garrett County Sheriff's Dept. Communications Operator Bill Wiltison noted that this accident occurred around 1:20 p.m. Friday; and a second, larger accident, involving more than 50 vehicles, began almost an hour later in the westbound lanes.

This second accident quickly turned into a nightmare involving a chain reaction with nearly 90 vehicles, including tractor trailers. Rescue workers found three vehicles with people trapped inside. The fog had not cleared as darkness settled hours later over Big Savage Mountain, hampering efforts to clear the accident sites. Ambulances responded from Allegany, Garrett and Somerset Counties transported the most critically injured, while a school bus was used to transport the less seriously injured to the Eastern Garrett Fire Department.

Figure 2. Photographs From May 23, 2003 Accident on Big Savage Mountain.

As operations wound up, the extent of the accident could be defined. Two patients died at the scene from injuries and 64 patients were transported to area hospitals. Approximately 90 vehicles were involved in both accidents, which included tractor trailers as well as passenger vehicles. Heavy fog was blamed for the accident. Interstate 68 remained closed for approximately 24 hours after the first accident occurred.

The accident location was near the I-68 cut on Big Savage Mountain which is 2,900 feet above sea level. In this area, foggy conditions are common in the spring and icy conditions are common in the fall on this stretch of road.

Maryland State Police Sgt. Terry Fisher, who lives on the mountain and oversees the roadside truck weigh station, noted that 50 vehicles collided in the snow here in 1991; and there was a 17- vehicle pileup seven years ago.

A meteorologist for the National Weather Service's Baltimore-Washington office explained that the weather situation that contributed to the chain-reaction accident was not unusual. The environment was very moist and there were low clouds which, with the higher terrain, set the conditions dense fog to form. This is common in the spring, especially with east-northeast moist air flow with air coming off the ocean into the higher elevations. There is approximately 1,800-foot difference in elevation between Cumberland, where there was no fog, and Frostburg, near where the accident occurred.

CCTV cameras installed along Interstate 68 and available on the Maryland Department of Transportation Web site showed clear views of traffic at Cumberland but a wall of gray farther west on the interstate. By 1:30 in the afternoon, visibility on top of Big Savage was estimated to be approximately 200 feet.

Fog Background

Fog is a cloud that forms at the surface of the earth. It consists of a multitude of minute water droplets suspended in the atmosphere. According to international definitions, fog is present when horizontal visibility drops below 0.62 miles or one kilometer. Heavy fog is defined as visibility below 0.25 miles.

Fogs of all types originate when the dew point and the air temperature become identical, and sufficient condensation nuclei are available in the air. This generally occurs two ways, the first by cooling the air to its dew point; advection, radiation, and upslope fog are examples of this type of fog. The second cause is a result of elevating the dew point by adding moisture to the air mass; steam fog and frontal fog are examples of this type. Fog seldom occurs when the dew point temperature differs from the air temperature by more than 4 degrees Fahrenheit and the wind speed is more than 10 m.p.h. There are four basic types of fog; radiation, advection, evaporation, and upslope.

Radiation fog is caused by the cooling of the air mass close to the earth's surface. The earth gives off long wave radiation, which on a clear night travels out into space. When the temperature drops to the dew point close to the ground, radiation fog can form. Radiation fog is also known as ground fog.

Advection fog results from the movement (advection) of warm, moist air from the south over a colder land mass. During the winter this is common when snow covers much of the ground. The snow cools the bottom portion of the moist air mass often resulting in condensation (fog). This type of fog can be widespread and very dangerous.

Evaporation fog is caused by cold air crossing over warmer bodies of water. The water evaporates its moisture into the colder air which immediately condenses it into clouds and fog. This is what looks like steam over inland lakes and rivers on a cold autumn or winter day.

Upslope fog is common near mountains such as around Big Savage. If the winds are out of the east, the air flows up as it rises in elevation approaching the mountains. This can cool the air to its dew point and result in widespread fog.

In the project area, Advection and Upslope fog are issues that are a concern at the higher elevations and Radiation fog is an issue at the lower elevations.

Project objective

The objective of this project is to install a system that will identify conditions of low visibility and notify approaching drivers of the limited visibility situation before they encounter it.

Report Outline

Following this Introduction, there is a discussion of similar projects and the technology they employed. With this background, the report examines the project site and identifies fog-prone areas. It then defines sensor locations and traffic sign locations within these areas. The SHA has an investment in RWIS infrastructure in this corridor. The next section identifies key components of this infrastructure. The final section of the report provides a description of various alternative approaches and recommends a specific solution. In this last section, the recommended solution is described in detail and costed.

Fog Detection Background

Before launching into the design of the fog detection system for the western I-68 corridor, it is useful to review several similar projects and to investigate the available technology to sense and responds to fog conditions

Similar Projects

A review of the literature revealed several similar projects that have resulted in operational fog detection systems. The reviews were useful in identifying the major hardware and suppliers as well as bracketing the costs for the system. Four of the more interesting of the reviewed projects are described below.

St. Albans West Virginia

The purpose of this system is to detect fog at the I-64 Bridge over the Kanawha River at St. Albans, West Virginia. When fog is detected, the system activates flashers to warn motorists to slow down and use caution. The system has an alarm and uses video camera to provide visual confirmation of the fog condition. The sensors are located one mile east and one mile west of the bridge near the St. Albans interchange. The system was budgeted at approximately $89,000 and the equipment was supplied by Nu-Metrics, Inc. of Uniontown, Pennsylvania.

Mobile, Alabama

At the other end of the financial spectrum is the Mobile project. This project expanded a fog detection and tunnel management system into a full incident management system on the seven-mile Bay Bridge and other segments of I-10 through Mobile, Alabama. This system included fog detection sensors, variable speed limit signs, lane control systems and Traffic Control Center renovations. The total cost of this system exceeded 6.5 million.

Fancy Gap, Virginia

This project installed a new visibility detection system on Interstate 77 on Fancy Gap Mountain. The project cost approximately $2.3 million. It was designed and installed by System Innovations Inc. of Fredericksburg, Virginia. The system incorporated an existing wind detection weather station that was installed by the Virginia Department of Transportation (VDOT) at mile marker 2. Other weather detection stations were installed at various locations on I-77. The stations are powered by solar charged batteries and use wireless radio to communicate weather information to VDOT. This type of weather detection station is currently used by airports and can measure visibility, temperature, humidity, barometric pressure, wind speed and wind direction. The system uses variable message boards to alert drivers on I-77 of foggy or windy conditions.

I-75 Fog Detection/Warning System

One of the most complex fog detection systems currently operational is the I-75 Fog Detection/ Warning System in Bradley and McMinn Counties, Tennessee. In December 1990, a chain-reaction collision involving 99 vehicles prompted the design and implementation of the fog detection and warning system on Interstate 75 in southeastern Tennessee. The system covers 19 miles including a three-mile, fog-prone section above the Hiwassee River and eight-mile sections on each side.

The system uses a central computer system to collect data from two weather stations, eight fog detectors, and 44 vehicle speed detectors. The system was designed by PB Farradyne. By continually monitoring fog and speed sensor data, the computer system predicts and detects conditions conducive to fog formation, and alerts managers when established threshold criteria are met. Highway Patrol personnel visually verify onsite conditions. The computer system correlates field sensor data with pre-determined response scenarios, which include advising motorists of prevailing conditions via flashing beacons atop six static signs, two HAR transmitters, and ten DMS; reducing speed limits using ten VSL signs; and restricting access to the affected highway section with ramp gates.

Center managers select pre-programmed DMS messages, pre-recorded HAR messages, and appropriate speed limits (i.e., 50 mph or 35 mph) based upon response scenarios proposed by the system. Under the worst-case scenario (i.e., visibility less than 240 feet), the Highway Patrol activates eight automatic ramp gates to close the interstate and detour traffic to US Route 11. The Fog Detection and Warning system was made operational in December of 1993. Crash records collected since that date indicate no reported crashes due to fog.

Similar Project Summary

The four projects were selected from among many possible examples to illustrate several points. The St. Albans project shows that the project need not cost millions of dollars to be effective. This fog detection system is targeted to a specific problem, river fog at a fog-prone bridge. The Mobile project shows how a fog detection project can cover a wide area and be integrated into an existing traffic control center. The Fancy Gap project illustrates a solution to a fog problem similar to that experienced at Big Savage and Keyser's Ridge. The fourth project, I-75 in Tennessee is an example of the most extensive traffic control system in operation in the United States that was installed as a remedy to a serious fog problem. The impetus for this project was a serious multi-vehicle accident similar to that experienced on I-68. The system uses virtually every traffic control device available to communicate with drivers. The reduced visibility response strategies include warning signs, warning radio messages, reduced speed limits, and in extreme conditions, complete closure of the Interstate highway.

Technology

The State Highway Administration operates approximately 40 Road Weather Information System (RWIS) stations across the state. Of importance to this project are two of these stations; one is east of the I-68 crest near Big Savage mountain (See Figure 3) the other is the near the I-68 and US 219 interchange at milepost 14.

Figure 3. I-68 RWIS Station Located Near Big Savage Mountain.

Each RWIS station supports a combination of technologies that use historic and current climatological data to develop road and weather information to aid in roadway-related decision making.

The three main elements of RWIS are environmental sensor system technology to collect data; models and other advanced processing systems to develop forecasts and tailor the information into an easily understood format; and dissemination platforms on which to display the tailored information.

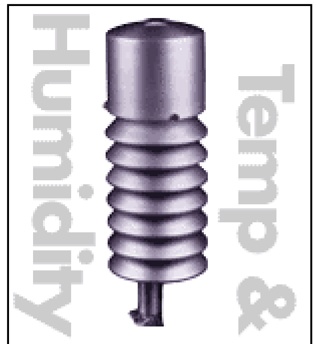
The sensing stations are the components of RWIS that provide environmental data. Many types of data can be collected, the most common type being weather - air temperature, amount and type of precipitation, visibility, dew point, relative humidity, and wind speed and direction, surface pavement temperature, subsurface temperature, surface condition (dry, wet, frozen), amount of deicing chemical on the roadway, and freezing point of the road surface. Of these sensors, the visibility sensor is the one that is of most importance to this project.

These data are collected by sensors placed at the roadside or in the roadway itself. A Remote Processing Unit (RPU) is housed in a field cabinet and provides the initial processing of the sensor data. It also provides the communications processing necessary to transmit the information to the next level of the system. This next level is a Server located in the SHA District 6 operations center in LaVale. This Server provides communications, collection, archiving, and distribution of the data. The raw data are used directly or in coordination with a service provider to prepare weather forecasts. Forecasts can be used to predict site-specific weather and pavement conditions. The data can be used locally in District 6, but are also transmitted to the Statewide Operations Center.

The primary sensors used at the RWIS site are described below.

Air Temperature & Relative Humidity

The RWIS weather system used by the SHA employs a Thies Air Temperature/Relative Humidity sensor that uses human hair as the relative humidity sensing element. Human hair is resistant to the rigors of harsh roadside environments where other approaches to measuring humidity require continual cleaning and calibration.



Air Temperature & Relative Humidity Sensor

In addition, the accuracy of the sensor improves the closer one approaches saturation, i.e., in foggy or nearly saturated conditions, the sensor reaches its maximum sensitivity. Two meteorological conditions associated with high humidity conditions are typically important in maintenance activities; fog and frost. Both fog and frost occur during moist to saturated atmospheric conditions when the measurement approach used in the Thies sensor is the most accurate. In addition to accuracy, this sensor has proven to be very reliable.

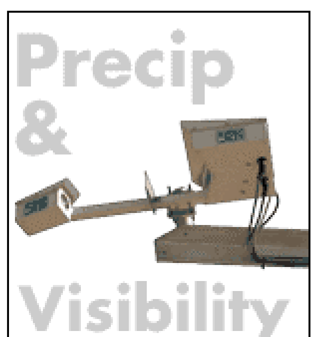
Wind Speed & Direction

The RWIS uses the R.M. Young wind speed/direction sensor. This sensor is noted for its reliability and ease of maintenance. Mechanical sensors have been the mainstays of the meteorological community for years. Meteorologists have used two basic approaches: separate wind vane and anemometer cups or the integral wind vane and propeller. For reliability with minimal maintenance the R.M. Young has proven to be an excellent sensor.

Wind Speed/Direction Sensor

Precipitation

One of the key elements in assessing the surface condition of the pavement is knowledge of the source of the moisture on the pavement surface. It is important to know whether precipitation is occurring or was the source of the moisture in order to discriminate it from frost, dew, absorption, or other human induced sources. These surface sensor devices look like hockey pucks and are extremely rugged



Precipitation and Visiblitiy Sensor

Visibility

For this project, the Visibility sensor is the key. This sensor can detect the type of precipitation (none, rain, snow or drizzle); precipitation intensity (light, moderate, or heavy); precipitation rate, liquid equivalent (in actual length per time units, e.g., cm/hr) and measurement of visibility.

Site Investigation

On October 6, 2003, representatives from the State Highway Administration, Sabra, Wang and Associates, and SSI investigated three locations on I-68 between Frostburg and the West Virginia state line where fog is a persistent problem: Big Savage, Keysers Ridge, and Friendsville.

At the site on Big Savage there was some concern that an additional fog sensor may be needed closer to the MD546 Bridge. Two potential locations for the advance warning signs were tentatively identified close to the existing permanent/portable VMS sites that already have power and phone.

For Keysers Ridge three signs were suggested: one on NB US219 near Rabbit Hollow Road, one on I-68 WB near Amish Rd, and one on I-68 EB east of Pigs Ear Road.

The third site investigated was in the valley near Friendsville near Exit 4. The experience has been that fog hangs in the valley, over the river around Friendsville. Considering the availability of utilities and the best location for sensors, a site just west of the Yough Bridge on the north side of I-68 was identified. One option would be to install a complete RWIS station with road and deck of the bridge sensors in addition to the visibility instrumentation.

Fog Hazard Area(s)

As noted above, the initial review of the western I-68 corridor identified three locations where fog is a hazard. Each of the three locations is discussed in the following sections. There is a description of the sensor location (the area where the initial formation of fog is expected); and a description of the warning sign locations (areas expected to be fog-free where drivers can obtain an adequate warning of the reduced visibility conditions ahead).

Big Savage

This is the location of the major accident that began this investigation. The overall profile of the highway from the US 219 interchange at milepost 22 to the Interchange at milepost 33 is shown in Figure 4.

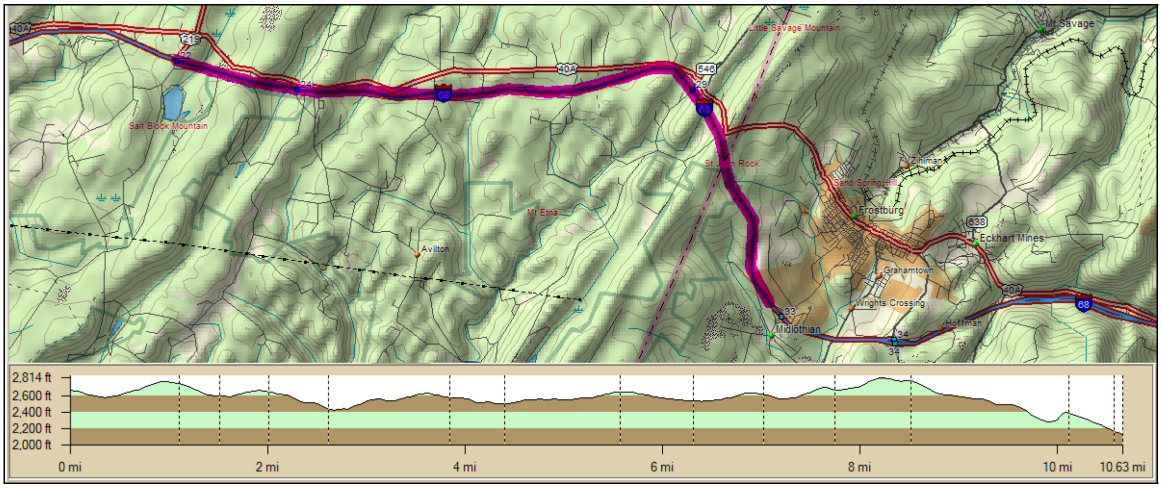


Figure 4. I-68 Profile From MP 22 to MP 33.

In this depiction, Big Savage is shown approximately 8.5 miles east of the US 219 Interchange. A key factor to note is the steep grade from the crest of Big Savage to the Interchange at milepost 33, a distance of approximately two miles. An existing visibility sensor is located at the eastbound Truck Weigh Station (approximate milepost 31). While this RWIS station is not at the crest, the difference in elevation is not expected to be significant in the detection of fog. It is planned, therefore, that the existing RWIS infrastructure be used for the fog detection.

When fog is detected, it is important that this information be communicated with the motorists before they encounter the foggy area. Since the types of fog most frequently expected on Big Savage are advection fog and upslope fog, and these types form at altitude and descend, it is important to locate the warning devices at lower altitudes. An excellent location for the westbound traffic approaching Big Savage is west of the Interchange with MD 36 (approximate milepost 33.7). The line of sight between the existing RWIS location and the proposed sign location is shown on Figure 5. The profile of the line of sight is shown at the top of this figure. Because the overall plan calls for the use of spread-spectrum radio communications, it is important to have clear lines of sight between the anticipated transmitter and receiver locations.

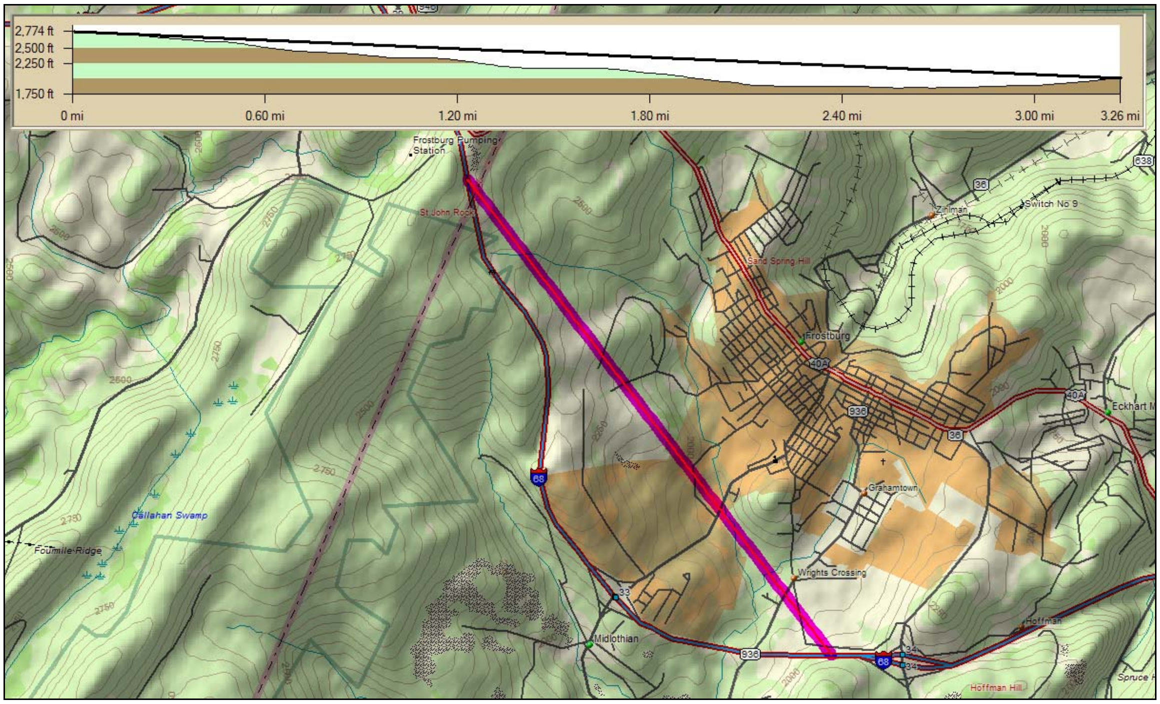


Figure 5. Line of Sight to Westbound Sign Location.

Locating the warning sign for the eastbound traffic is more difficult since it is not possible to have a line of sight communications between the RWIS and the sign location because of the crest of Big Savage.

Line of sight to the west will require a repeater. Two possibilities were investigated. The first is shown in Figure 6. With this alternative, the repeater would be installed on MD 247 at the crest and the warning sign would be located at approximately milepost 25.5.

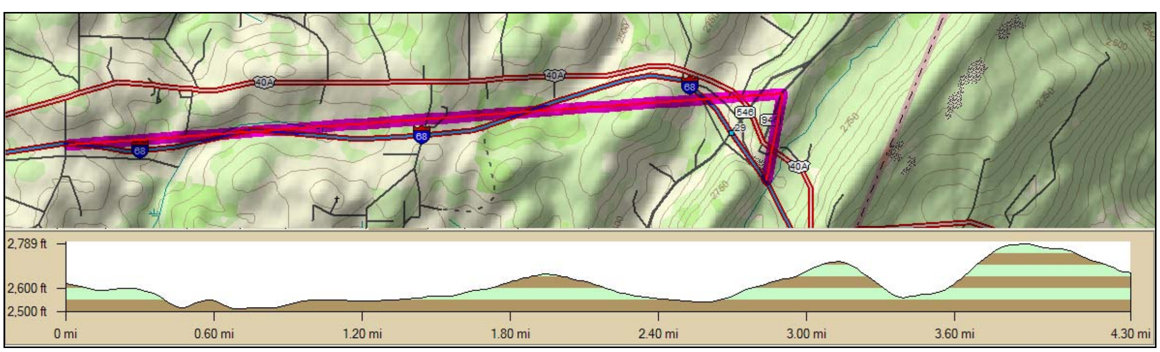


Figure 6. Eastbound Warning Sign, Repeater on MD 246.

Another alternative is to locate the repeater near the crest within the right of way of US 40A. This alternative is shown on Figure 7.

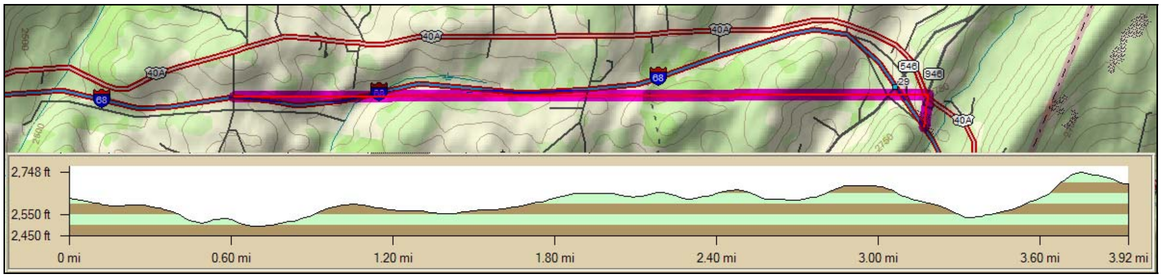


Figure 7. Eastbound Warning Sign, Repeater on US 40A.

The better location can only be determined after testing the radio transmissions, but either location would have material and construction cost.

Keysers Ridge

A photograph of the existing RWIS station at Keysers Ridge is shown in Figure 8.

An overview of the Keysers Ridge location is shown on the following page in Figure 9. The profile shows the elevation of the RWIS 2.4 miles from the west side of the illustration (approximately milepost 11.5). This would be the most likely location for the eastbound warning sign.

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Figure 8. Keysers Ridge RWIS station.

For the westbound traffic, a sign placed near milepost 15.5 is as far east as is possible without using a repeater because of the ridge line east of Lake Louise.

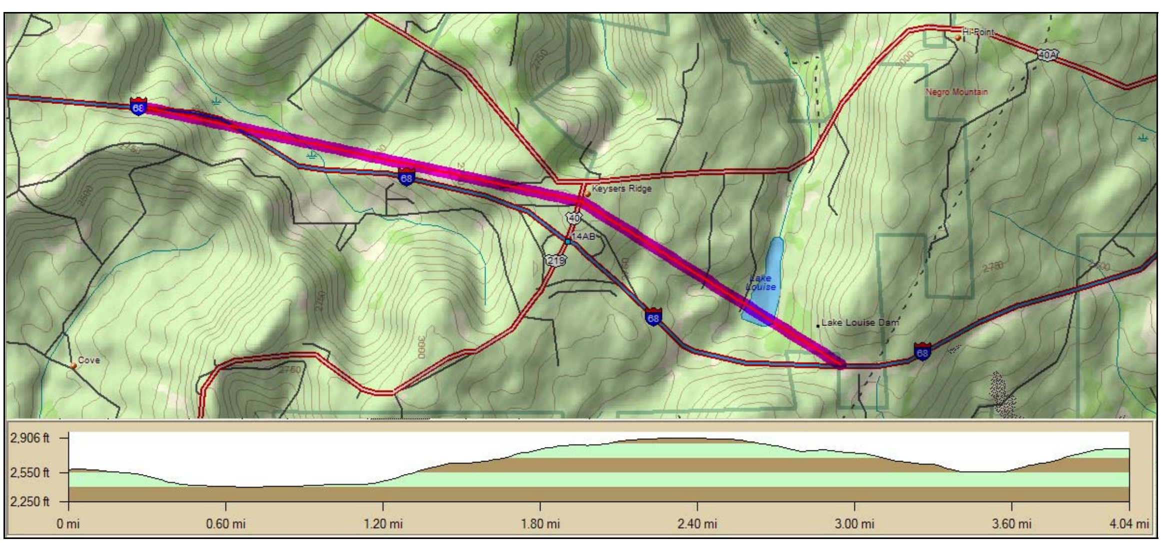


Figure 9. Keysers Ridge Line of Sight.

While traffic on I-68 is one issue, there is another approach problem at this location, the northbound traffic on US 219. To inform this traffic of a reduced visibility problem, a third warning sign could be placed on US 219 one quarter of a mile north of Rabbit Hollow Road. As shown on Figure 10, there should be a line of sight path between this location and the existing RWIS site that would enable communications.

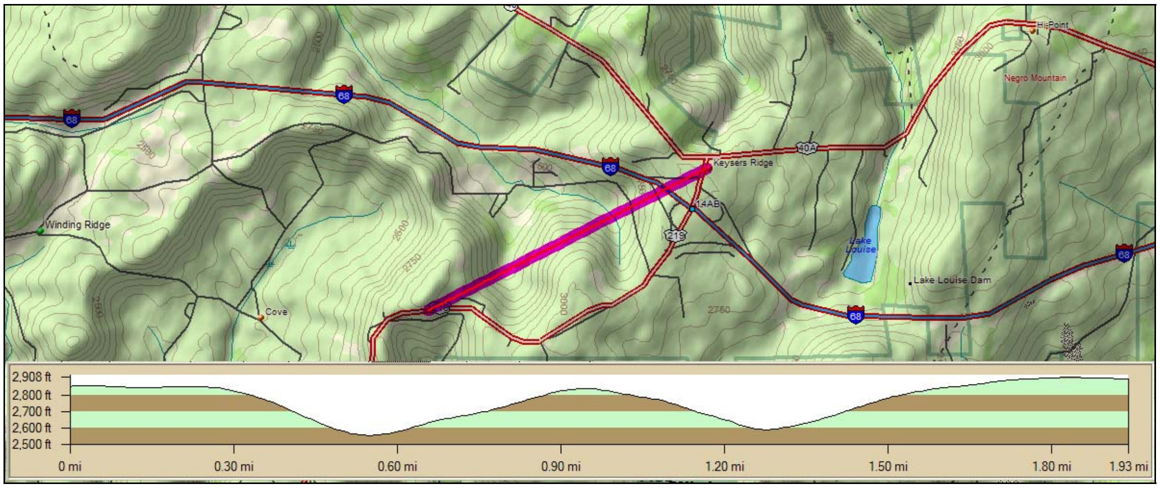


Figure 10. Keysers Ridge - US 219 Line of Sight.

Friendsville

This location differs from the others in several important aspects: the type of expected fog; the existence of existing infrastructure; the profile of the highway; and the relatively poor lines of sight, especially to the west. While the other two areas are threatened with advection fog and upslope fog that are a concern at the higher elevations, Radiation fog, also called Ground fog is the primary concern in this valley. A good potential location for the fog sensor was identified just east of the Interchange at milepost 4 on the north shoulder of I-68. A power source was located with 100 yards of the location. Although not necessary for this fog detection and warning project, it would likely be practical to install a full RWIS station similar to that located at the other two locations. The photograph in Figure 11 shows the sight looking westward from the bridge. The equipment cabinet on the right contains the power supply for the overhead lighting.

Figure 11. Potential Location for a RWIS Station at Friendsville.

As can be seen o n Figure 12, the overall alignment of I-68 in Bear Creek Valley is in the shape of a giant “S”. Because of the topography and the road alignment, the lines of sight from the valley to both the east and west are far from optimum. The line of sight to the east allows a warning sign to be installed at milepost 6.0 (approximately). While not as far upstream of the westbound traffic as might be desirable, this location still offers more than a 300 foot difference in elevation which should provide a warning before the traffic encounters the ground fog. The line of sight to the west is more limited at approximately one mile and 200 foot difference in elevation.

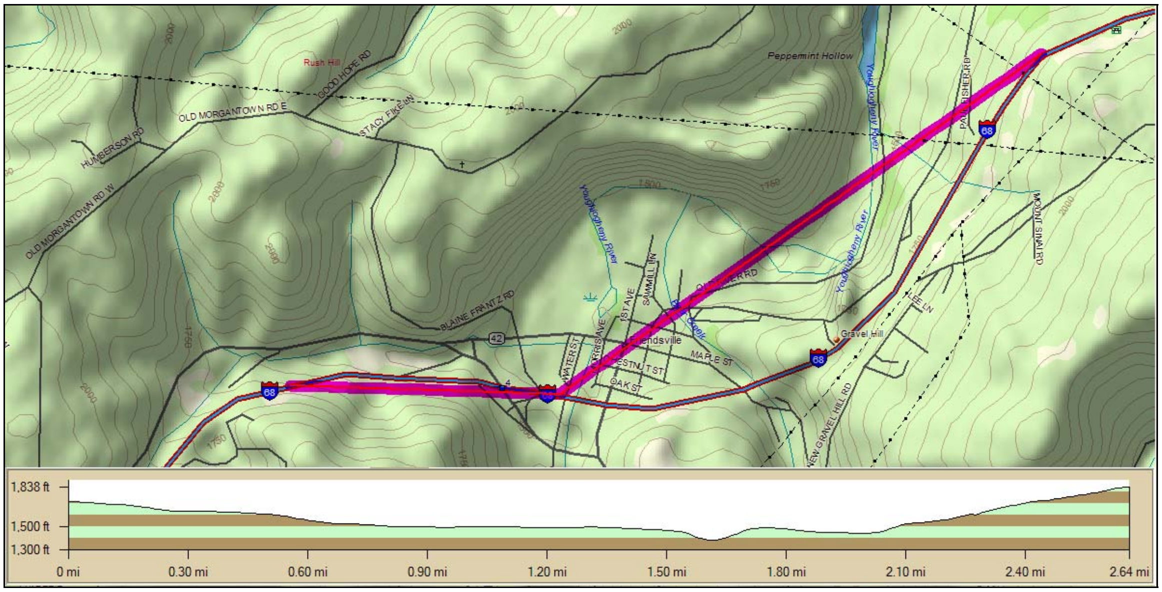


Figure 12. Friendsville Lines of Sight.

Recommended System

The recommended system makes maximum use of the existing infrastructure. It uses the existing RWIS at Big Savage and Keysers Ridge, and recommends the installation of a similar new RWIS system at Friendsville. Each RWIS site communicates to the District 6 Server via dial-up telephone, and controls two or more warning signs via spread spectrum radio. The warning signs are powered by solar panels and batteries.

This section provides a description of the equipment components used in this project. This is followed by a listing of each component used at each of the three RWIS sites and a cost estimate.

Equipment Description

There are four significant subsystems that are employed on this project: the RWIS equipment, the solar power system, the warning sign system, and the spread spectrum radio communications system.

RWIS

The RWIS station is a standard station similar to that installed at Big Savage and Keysers Ridge. The devices to be furnished and installed may include the following:

- Remote Processing Unit (RPU),
- 30' Roadway Tower,
- Surface Sensors (roadway and bridge deck),
- Subsurface Temperature Sensor,
- Air Temperature/Relative Humidity Sensor,
- Wind Speed/Direction sensor,
- Present Weather and Visibility Sensor,
- Color video camera, and,
- System Software

Solar Power System

Because the warning signs and radios must be located in areas where AC power is difficult and expensive to provide, the system is designed to use solar power. At each warning sign, the solar power system will provide power for:

- the flashing beacons;
- the spread spectrum radio; and,
- the solar panel controller.

The key elements in the design of the solar power system are the size of the batteries and the size of the solar panels that are used to recharge the batteries. The system is designed to operate the flashers for 72 hours with no significant sun light. Sunlight is converted by the solar panels to electrical energy and the batteries store the electrical energy. The solar panels are connected to the batteries through a controller which regulates the charging and discharging rate of the batteries. Each of the parts of the solar power system are described below:

Solar Panels: Each assembly shall use two solar panels. The panels shall be Siemens SM55 or equivalent. The solar panels are off the shelf items and warranted for 20 years. They are mounted at the top of a 14 foot mounting pole which uses a bracket to tilt the panels to the south at the optimum angle. The battery and electronics enclosure is also mounted on this pole. The solar panels use 36 solar cells. These cells make optimum use of the module surface area because of their square shape. They are highly efficient and provide the maximum power possible under low light level conditions. The hardened front glass has excellent light transmitting properties and protects the module against most adverse environmental conditions such as hail or ice. The solar cells are laminated in EVA (ethylene-vinyl acetate) between a multilayer rear film and the front glass. This permanently laminated assembly protects the cells against moisture and ensures electrical insulation. The panel is supported by a torsion-resistant module frame made of anodized aluminum.

Controller: The controller manages the charge of the batteries. The controller is a solid state device and provides temperature compensated charging so that the rate of charge is controlled for both temperature and state of charge variations. The controller will shut off charging when the battery reaches a charge of 15.2 VDC. The controller will disconnect the load when the battery voltage reaches 11.4VDC. These set points have been established to prevent damage to the battery from an overcharge condition or a low voltage condition. The controller also has a manual disconnect switch that allows one to electrically disconnect the batteries from the system. The controller uses an LCD display to show the battery voltage, array current, and load current.

Battery: The battery stores the electrical energy which powers the load. Batteries are maintenance free sealed gel, absorbed mat technology. If the system is 'knocked down' by accident and the battery is punctured, there will be little to no acid spilled due to the absorbed mat technology. The battery type shall be a sealed, maintenance-free, valve-regulated design. The battery shall use an Absorbed Glass Mat (AGM) to suspend the electrolyte. The capacity of each battery shall be 115Ah at 25°. Each battery shall have a copolymer polypropylene case and cover and have non-removable, pressure-regulated, flame arresting safety valves. The rated operating temperature shall be from -40°C to +72°C. The battery shall have a self-discharge rate better than 1% per month at 25°C.

Battery and Electronics Enclosure: The enclosure houses two 115 Ah batteries (Group 27) and the electronics in two separate compartments. The enclosure is fabricated from aluminum with a minimum wall thickness of 0.125 inches. The approximate dimensions are 26” x 15” x 15”. The battery compartment has a minimum of 1/2” Styrofoam sheeting to minimize heat transfer between the batteries and the enclosure wall.

Warning Sign

The purpose of the warning signs is to inform the motorist that there is a reduced visibility situation ahead of them. This is a task similar to the "Shazam" signs used by the SHA to inform motorists of a Highway Advisory Radio (HAR) broadcast. We recommend, therefore, that the "Reduced Visibility" sign be similar in design and operation. Flashing LED beacons will be installed at each sign, they are actuated to flash when a special reduced visibility condition is sensed at the associated RWIS. The details of the sign construction are provided in the Appendix.

LED Displays: The LED display beacons are a nominal 12" in size. The LED lamps are fabricated from TSAllnGaP material. The LED elements shall be optimally matched and provide a uniform amber color output. The lamps incorporate multiple main circuits. All lamps use a self-regulating circuit to accommodate input voltages from 10.5 VDC to 18.0 VDC.

Flasher: The flasher is a 12VDC, solid state flasher that consumes negligible power during operation. The unit supports two flasher outputs. When flashing, the unit will have an output duty cycle of 50% per lamp and be capable of 50 to 60 flashes per minute for each lamp. The flasher is housed in the Battery and Electronics Enclosure.

Spread-spectrum Radio

The radio will be a standard, off-the-shelf unit designed for the traffic control and SCADA industries. The radio system will be one designed for remote data collection applications or any applications that require the transfer of contact closures.

The basic design calls for a Point to Multi-point configuration where contact closures are transmitted from a central location to multiple receivers (warning signs). The radio system uses license-free frequency hopping, spread spectrum technology. This technology can provide reliable, long-range, wireless communications (up to 20 miles).

The system will employ a radio transmitter at each of the three RWIS sites. When the RWIS equipment detects a low visibility situation, it

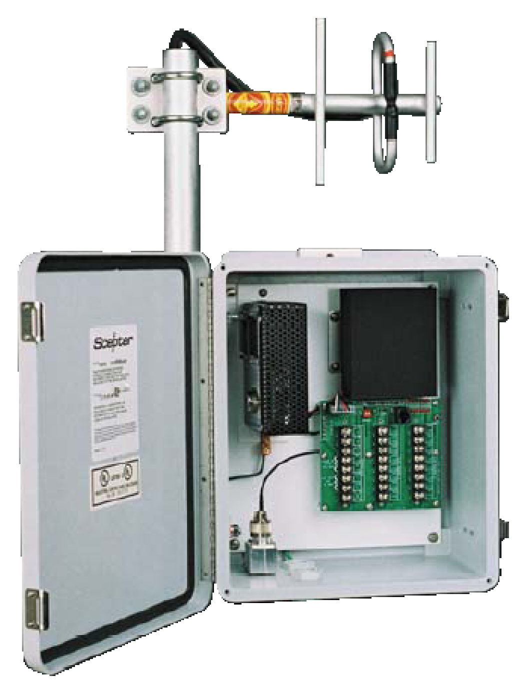


Figure 14. Radio Receiving Equipment and Cabinet.

provides a contact closure. The contact closure is fed to the radio system and then transmitted to the warning signs. The radio is housed separately from other equipment at both the RWIS transmitter sites and the warning sign receiver sites.

Each transmitter site uses a gain, vertical, omni-directional antenna. Each receive site uses a Yagi directional antenna as shown in Figure 13.

At each warning sign site, the radio equipment cabinet is mounted on the solar panel pole. The Yagi antenna is mounted on the same pole. At the RWIS sites, the vertical antenna is mounted on the site tower and the radio transmitter cabinet is also mounted on the tower.

At one location, Big Savage, it is not possible to have line of sight communications between the RWIS site and the warning sign located to the west of this location. A radio repeater must be used at this location. The repeater will use two yagi antennas; one pointed at the RWIS station, the other at the warning sign. The antennas and the repeater radio equipment will be mounted on a separate 14 foot, 4.5" diameter, aluminum pole that shall be similar to that used to support the solar panels

Operation Description

The basic plan is to use the existing RWIS equipment to identify low visibility situations. When this condition exists, the system will turn on warning signs to alert drivers approaching the low visibility condition. At Friendsville, we are proposing to install a new RWIS station that is similar to the two existing. All three sites are configured using the equipment described in the previous section. Each site is independent and responding to the local measures of visibility. Each site can be overridden by a direct command from District 6.

Site-specific Components and Costs

The specific components recommended for each site are described and costed in this section. Although each site is unique, they share the same basic features:

- Low visibility detected with standard RWIS equipment.
- Warning signs are activated to alert drivers to the situation.
- At the warning sign locations, electrical power is provided by a solar system.
- Communications between the RWIS sites and the signs is provided by radio.
- The RWIS sited are connected to District 6 via dial-up telephone.

Big Savage

The plan for Big Savage uses the existing RWIS infrastructure for the reduced visibility input. The equipment is modified to provide the contact closure interface with the radio transmitter. Because the crest is approximately ½ mile west of the existing site, we have planned to use a repeater to transmit the radio signal to the west warning sign location (for Eastbound traffic). There is a clear line of sight transmission link to the east warning sign location (Westbound traffic).

The following units shall be installed at the Big Savage location.

Table 1. Big Savage Location Cost Estimate.

Quantity	Description	Unit Cost	Extension
LS	Furnish and Install "Scan Sentry Alarming and Alerting software on the District 6 Server.		$5,000
LS	Modify Existing RWIS to provide contact closure under low visibility conditions.		2,500
1	Furnish and Install Radio Transmitter, Cabinet, and Omni-directional Antenna.	5,000	5,000
3	Furnish and Install Solar Panel Power System (Repeater site and two warning signs)	7,500	22,500
1	Furnish and Install Radio Repeater with support pole and two Yagi antennas	7,000	7,000
2	Furnish and Install Warning Sign with LED's and Flasher and Radio Receiver with Yagi.	13,000	26,000
LS	Contingency		7,000
Total			75,000

Keysers Ridge

The plan for Keysers Ridge is identical to that at Big Savage. It uses the existing RWIS infrastructure for the reduced visibility input. The equipment is modified to provide the contact closure interface with the radio transmitter. There is one minor variation. There are three warning signs at this location: the eastbound and westbound on I-68, and there is a sign for northbound traffic on US 219. There are clear lines of sight to all three locations.

The following units shall be installed at the Keysers Ridge location.

Table 2. Keysers Ridge Location Cost Estimate

Quantity	Description	Unit Cost	Extension
LS	Modify Existing RWIS to provide contact closure under low visibility conditions.	2,500	2,500
1	Furnish and Install Radio Transmitter, Cabinet, and Omni-directional Antenna.	5,000	5,000
3	Furnish and Install Solar Panel Power System (Three warning signs)	7,500	22,500
3	Furnish and Install Warning Sign with LED's and Flasher and Radio Receiver with Yagi	13,000	39,000
LS	Contingency		6,000
Total		-	75,000

Friendsville

This location differs from the others in two significant ways: there is no existing RWIS infrastructure and the location is in a valley rather than a mountain top. To keep the operation compatible with the other locations, we are recommending that a new RWIS station be installed on the north side of I-68 just east of the interchange as shown in Figure 14. The site survey indicted that existing electrical power and telephone are located within 300 feet of the proposed location and can be provided at reasonable cost.

As with the other locations, the operational plan would turn on two warning signs, one for eastbound the other for westbound traffic, when a low visibility condition is sensed.

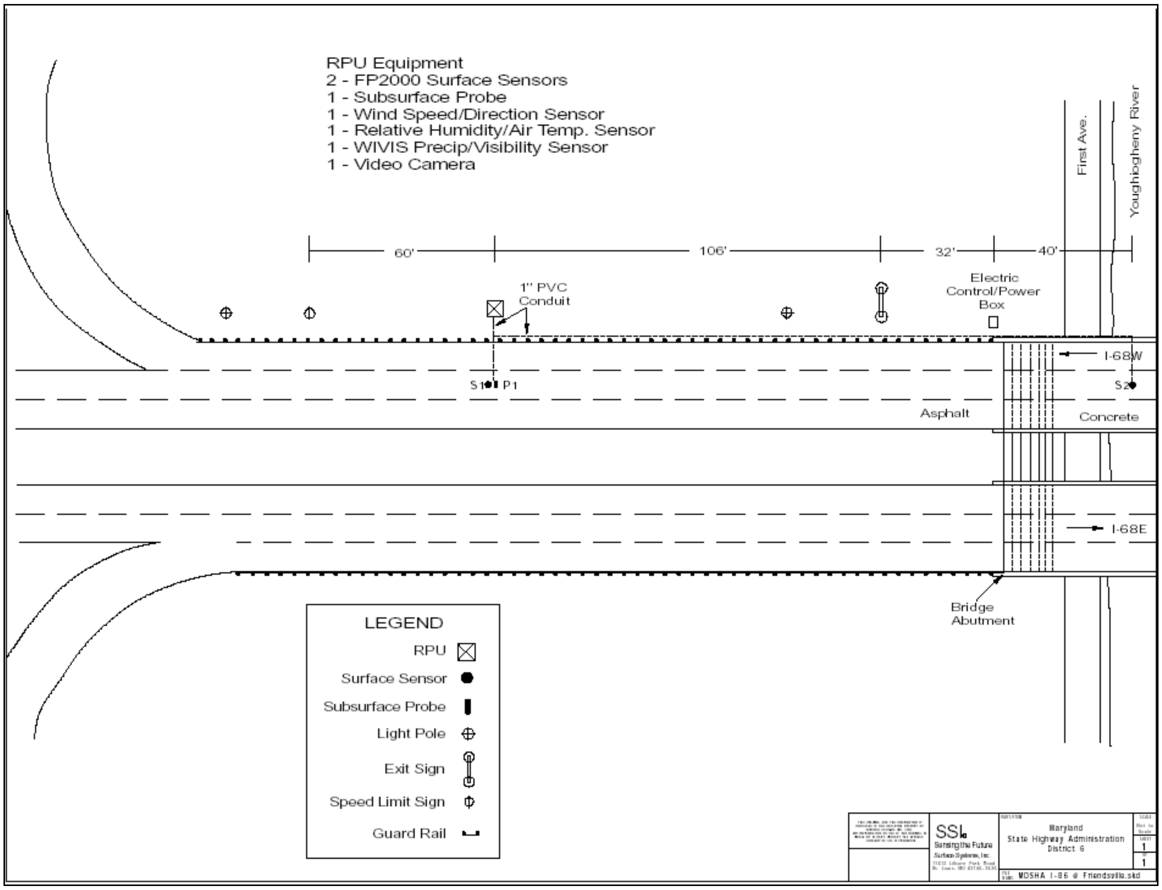
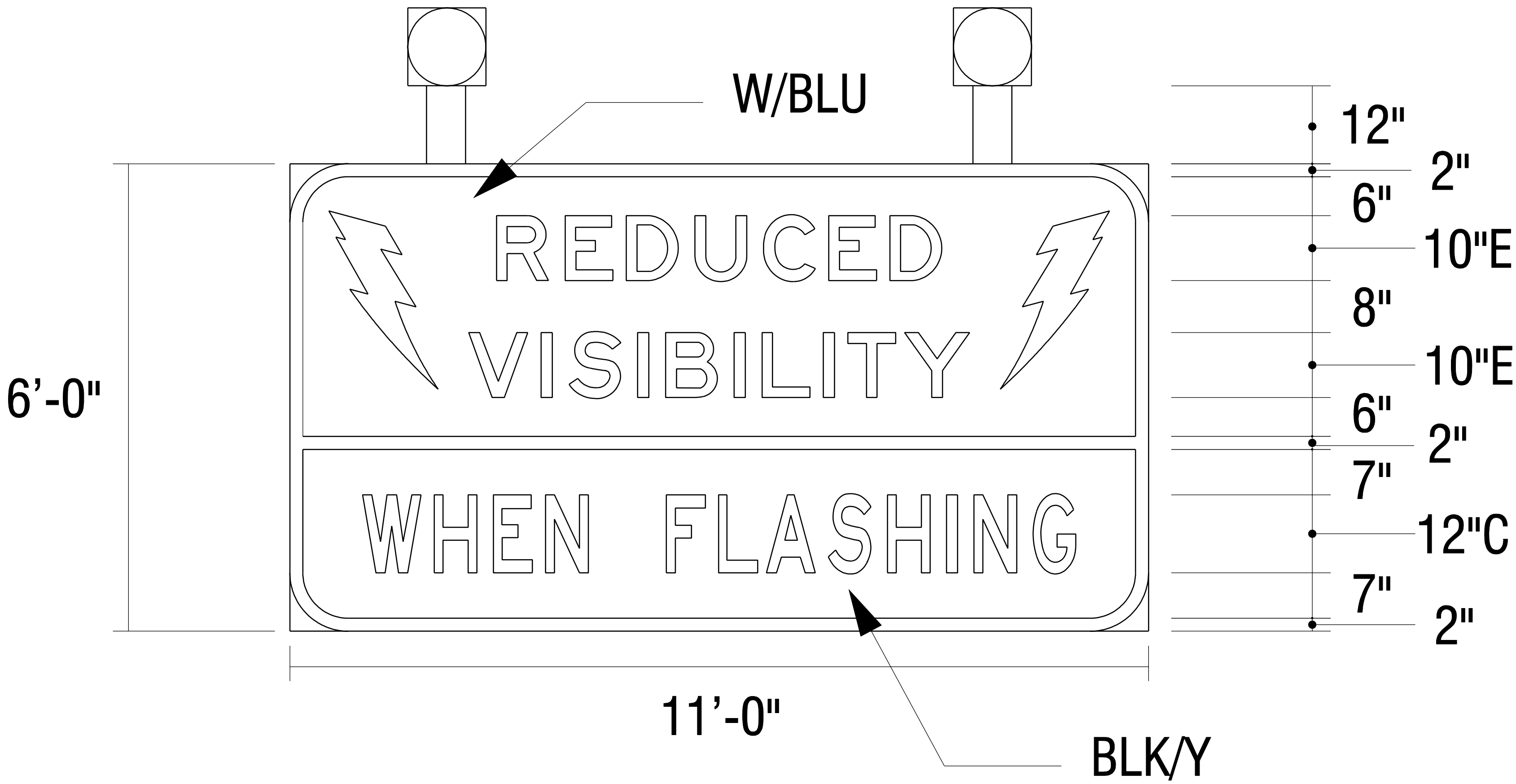


Figure 15. Proposed RWIS location at Friendsville.

The following items shall be installed at the Friendsville location.

Table 3. Friendsville Location Cost Estimate.

Quantity	Description	Unit Cost	Extension
LS	Furnish and Install new RWIS station that provides contact closure under low visibility conditions.	60,000	60,000
1	Furnish and Install Radio Transmitter, Cabinet, and Omni-directional Antenna.	5,000	5,000
2	Furnish and Install Solar Panel Power System (Two warning signs)	7,500	15,000
2	Furnish and Install Warning Sign with LED's, Flasher, and Radio Receiver with Yagi.	13,000	26,000
LS	Electrical Power and Telephone Connect		5,000
LS	Contingency		14,000
Total		-	125,000



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I-68 Fog Detection System Planning Report

APPENDIX
WARNING SIGN DETAIL