Western States One-Stop Shop for Rural Traveler Information

Research on *Clarus* System Data

www.its.dot.gov/index.htm

Final Report — September 30, 2011

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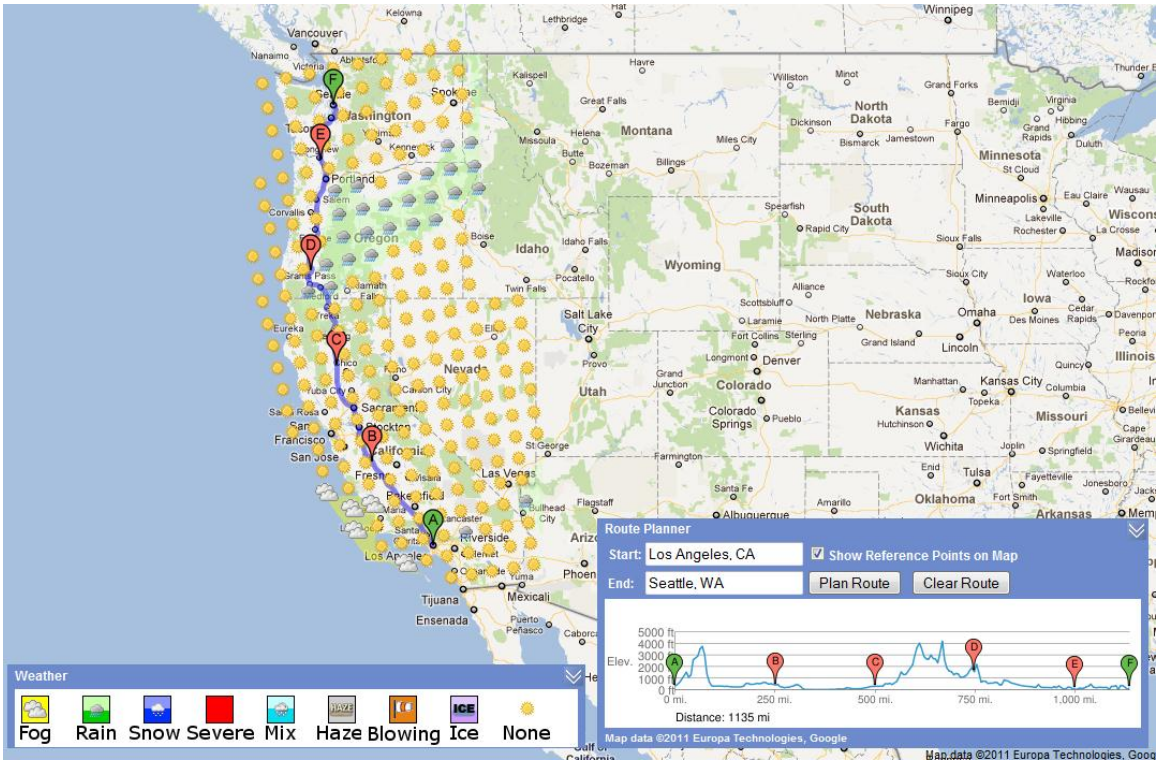

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16. Abstract

Weather is a primary item of interest to travelers, but is generally scattered of numerous sources and in varying formats, making it difficult to assemble prior to travel. Within this project, a website was developed to display *Clarus* ESS data, along with other information streams such as DOT Intelligent Transportation System (ITS) field elements, CCTV, planned and active closures, incidents, weather sensor readings from non-DOT sources, National Weather Service forecast information, etc. covering all of California, Oregon, Washington and Nevada. The developed product displays weather information for this region in a manner that is easily accessed and understood by users. There remain a number of challenges for subsequent development including optimization of code to support a greater number of prospective users and implementation for further interface elements, particularly to enhance route planning functionality. "Information at a Glance" was achieved in presenting information to users by way of intuitive, graphical displays. User survey results and data provided by Google Analytics™ indicated that the website has been well examined and received by users. Based on the work completed during this project, a mechanism to provide travelers with comprehensive weather and highway information across state and jurisdictional boundaries was demonstrated.

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Preface / Acknowledgements

The authors thank the Federal Highway Administration for funding this research. Thanks to Sean Campbell and Ian Turnbull of Caltrans for their guidance, input and assistance in establishing the original concept that led to this work. Thanks also to the members of the Western States Rural Transportation Consortium, specifically California, Nevada, Oregon and Washington and their respective Departments of Transportation, for their support of this work, including the provision of the various transportation-related data streams, as well as guidance and feedback.

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Executive Summary

One of the primary items of interest to travelers on the nation's roads, particularly those who will be traveling long distances, is the weather they will encounter en-route. While existing real-time traveler information services provide some weather and other information to travelers, the breadth and depth of useful information currently offered is limited. Real-time traveler weather information is a valuable tool in maintaining and enhancing both traveler safety and mobility. From a safety perspective, it is important for travelers to know before a trip about potential challenges that may impact their travel, including snow, ice, high winds, fires and other hazards that may degrade mobility. While such information may currently be available through a variety of sources, there is inconsistency in the types and quality of information available. In addition, the information is generally scattered over numerous web-based (and sometimes non-web-based) sources, meaning travelers must spend significant amounts of time assembling this information before making a trip.

To address the shortcomings of current web-based weather information sources for travelers (and DOT personnel), this project has developed a website displaying multi-state *Clarus* ESS data, along with other information streams as available, such as DOT Intelligent Transportation System (ITS) field elements, CCTV, planned and active closures, incidents, weather sensor readings from non-DOT sources, National Weather Service forecast information, etc. The objective of this project was to integrate a variety of real-time information together in a single web-based location and in a user-friendly format. The region covered by this work includes all of California, Oregon, Washington and Nevada. The developed product displays weather information for this region in a manner that is easily accessed and understood by users. In addition to weather information, the product displays other data streams as available. As a result of this work, the use and presentation of *Clarus* data across multiple states in conjunction with other traveler information streams is demonstrated by providing travelers and agency personnel with a useful planning and management mechanism.

Development of the website presented a number of challenges including implementing effective visual representations of the associated information and efficient server- and client-side coding to present a smooth, intuitive interface to users. There remain a number of challenges for subsequent development including optimization of code to support a greater number of prospective users and implementation for further interface elements, particularly to enhance route planning functionality. "Information at a Glance" was achieved in presenting information to users by way of intuitive, graphical displays.

The user survey results and data provided by Google Analytics™ indicated that the website has been well examined and received by users. Of course, the limited sample size of survey results collected from users means that no firm conclusions can be drawn, but the initial feedback received has been positive and also provided useful insights into improvements and modifications that can be pursued in future work. With respect to user feedback, future surveys should target the goods movement/trucking industry and law enforcement user groups, as no responses were obtained from these during the present project. The information provided by Google Analytics™ indicates that the system was viewed by a number of users from a number of different areas in the study region, with most users remaining on the site for an extended period of time.

Based on the work completed during this project, a mechanism to provide travelers with comprehensive weather and highway information across state and jurisdictional boundaries was demonstrated. The prototype website provides travelers in rural areas with a comprehensive source of information for the planning of their trip. The availability of this information in one location will save travelers time in planning their trip, as well as will help make that trip more safely and with minimumal delay.

Chapter 1 Introduction

One of the primary items of interest to travelers on the nation's roads, particularly those who will be traveling long distances, is the weather they will encounter en-route. While existing real-time traveler information services provide some weather and other information to travelers, the breadth and depth of useful information currently offered is limited. Existing systems are typically designed to conform to specific jurisdictional lines, such as state boundaries, whereas many trips will span multiple such jurisdictions. While many entities have sought to provide traveler information via the Internet, the result has been considerable variation in the level of detail provided. This is particularly true of weather information, which is often provided only for major routes in a manner that may not be decipherable to the average traveler.

Real-time traveler weather information is a valuable tool in maintaining and enhancing both traveler safety and mobility. From a safety perspective, it is important for travelers to know before a trip about potential challenges that may impact their travel, including snow, ice, high winds, fires and other hazards that may degrade mobility. While such information may currently be available through a variety of sources, there is inconsistency in the types and quality of information available. In addition, the information is generally scattered over numerous web-based (and sometimes non-web-based) sources, meaning travelers must spend significant amounts of time assembling this information before making a trip. As a result of the effort involved with compiling this information, many travelers do not seek out all the information they need, if they even choose to seek that information at all. This may result in increased delays and diminished safety for the traveler.

Previous work completed by the Western Transportation Institute has explored the acquisition and dissemination of various traveler information elements at various spatial levels. This includes the provision of weather and traveler data through different website platforms. One such source is WeatherShare (***1***), which compiles available road weather data from various sources in California, including RWIS ESS data, and presents it in a map-based format. Additionally, the Integrated Corridor Management Clearinghouse (***2***) and One-Stop Shop (***3***) platforms employ this same weather data, along with other traveler information streams (CCTV, chain controls, etc.) to provide a map-based display of conditions throughout California. In all cases, these platforms combine weather data from various sources to provide detailed information in a comprehensible format regarding current and forecast conditions (see Figure 1-1). When combined with multiple data streams such as closed circuit television cameras (CCTV), this weather information provides Department of Transportation (DOT) personnel and travelers with a more complete picture of data at a route-specific level.

While the previous efforts have led to the development of systems that provide more useful information to travelers and agency personnel at a route level, little work has been performed to extend these systems to cover broad regions (i.e., multiple states). At a local level, many travelers are making trips that cross jurisdictional boundaries, requiring them to visit multiple web pages to obtain critical trip-planning information, particularly weather data and forecasts. Similarly, DOT personnel along state borders often need to know what conditions are outside of their jurisdiction in order to manage operations. At a national level, other groups, specifically truck drivers, are making long-distance trips where weather information would be useful, but is difficult to obtain. In short, the current

approach to providing weather information to these user communities often does not meet their primary needs.

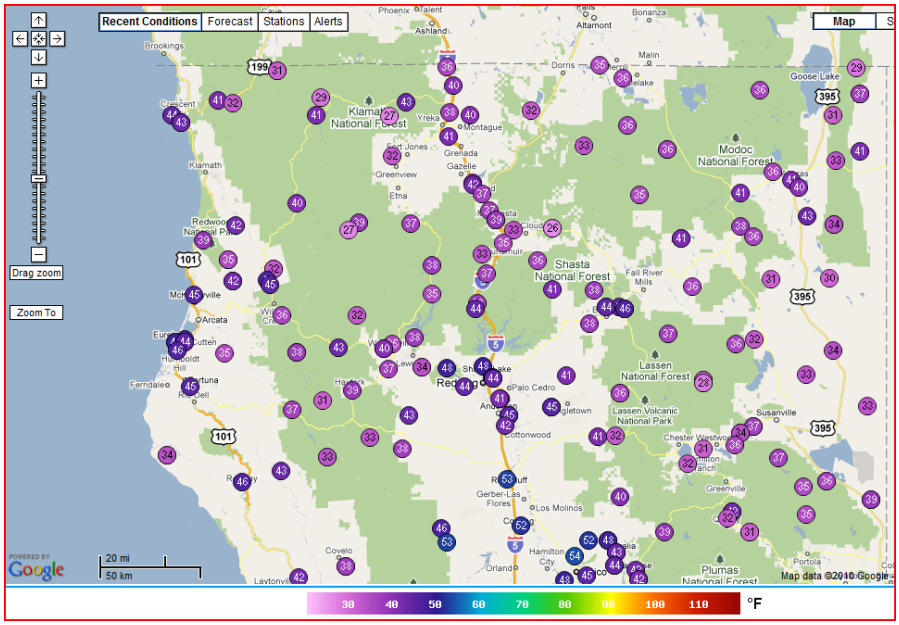

Figure 1-1. Screenshot of temperatures in northern California from WeatherShare (Data Source: MADIS, Mesowest, Caltrans)

Project Motivation

To address the shortcomings of current web-based weather information sources for travelers (and DOT personnel), this project has developed a website displaying multi-state *Clarus* ESS data, along with other information streams as available, such as DOT Intelligent Transportation System (ITS) field elements, CCTV, planned and active closures, incidents, weather sensor readings from non-DOT sources, National Weather Service forecast information, etc. The objective of this project was to integrate a variety of real-time information together in a single web-based location and in a user-friendly format. This work built upon the previously cited efforts, particularly One-Stop Shop, which laid the technological foundations for how such information is acquired and displayed. The region covered by this work includes all of California, Oregon, Washington and Nevada. The developed product displays weather information for this region in a manner that is easily accessed and understood by users. In addition to weather information, the product displays other data streams as available. As a result of this work, the use and presentation of *Clarus* data across multiple states in conjunction with other traveler information streams is demonstrated by providing travelers and agency personnel with a useful planning and management mechanism.

The system discussed in this report has been developed primarily for the traveling public, specifically highway travelers making longer distance trips across multiple jurisdictions/states. For the traveling public, the developed system will assist in making travel decisions when faced with adverse weather (e.g., rain, snow, sleet, wet pavement, snowy pavement, icy pavement, high winds, flooding, etc.). Additionally, as state transportation agencies increasingly adopt an “operations” approach to their highway networks, their focus will be on improving the use of existing assets. The real-time

information capability offered by *Clarus*' ESS data, as well as other streams, can help agencies to manage the system better.

Report Organization

This report is divided into five chapters. Chapter 1 has introduced the problem and the approach to addressing it. Chapter 2 presents an overview of the Concept of Operations and Requirements that were established to guide the development of the One-Stop Shop website. Chapter 3 provides a discussion of the system's design and development. Chapter 4 presents the results of a user survey, as well as general website usage trends and statistics. Finally, Chapter 5 presents the conclusions and recommendations that can be drawn from this work.

Chapter 2 Concept of Operations and Requirements

As part of the development of the Western States One-Stop Shop, a concept of operations and a requirements document were compiled. The concept of operations document provided a high level "vision" for the system, including general functionality as related to identified stakeholder groups, as well as the anticipated technical system details. The requirements document translated the system concept/concept of operations into a series of statements describing what the system shall do, and addressed issues with respect to data quality: the expected updating frequency of data being fed into the website, and any quality checking processes that needed to be used before data is published. The following sections provide a high-level overview of the concept of operations and requirements documents. Note that for brevity, the information provided in this chapter is an abbreviated form of the documents (***4, 5***) produced during the course of the project. These documents should be referred to for more detailed information.

Concept of Operations

The initial step in creating the prototype Western States One-Stop Shop was the development of a concept of operations document. This concept of operations provided a high-level, user-oriented perspective on how the system would work. It served as an important guidance document, because it assisted the research team in prioritizing which data elements were most important to include, and how the user interface should be structured to maximize user convenience.

Typically, a survey of potential users would be conducted prior to the development of a concept of operations. However, given the nature of the proposed One-Stop Shop and its shift from the traditional format of web-based traveler information, the research team decided it would be more advantageous to develop a prototype website first. By presenting users with a prototype that they could actually test and evaluate, the researchers believed that they would obtain more useful feedback on modifications and improvements.

Users

In order to develop a concept of operations for the One-Stop Shop, researchers needed to understand who would be using the website and how they would be accessing it. The following sections provide an overview of the primary anticipated users of the One-Stop Shop.

Long Distance Travelers

The primary user group that the system will serve is long-distance travelers seeking real-time and near real-time information as they travel on weather, road conditions, etc. Specifically, this group includes motorists who are making journeys over a relatively substantial distance (as opposed to

traveling locally). Note that this group does not include goods movement operators (truck drivers), as their traveler information needs are different (this group is discussed in a later section).

Long-distance travelers may include users who have employed a route before, or who are using a route for the first time (vacationers, business travelers, etc.). The information required by this group is varied, but typically will include the need for timely weather (current and forecast), roadway conditions (construction activities, incidents, closures, chain requirements, etc.), and additional information such as the location of rest areas. In addition, imagery from CCTV cameras may also be of use to such travelers, as it provides a visual indication of what the area looks like (particularly with respect to weather).

This group is expected to access web-based traveler information both before their trip, as well as during their trip. Information accessed before the trip would be obtained for the purposes of planning the journey (route planning, familiarization, etc.). Information accessed during the trip (either before beginning travel for that day or while traveling), would be used for obtaining more up-to-date information regarding their present or upcoming travel segment. Information accessed during the trip would be obtained through the use of smartphones, wireless web access at rest areas, and so forth.

To address the needs of this user group, the system will attempt to provide a number of different elements of traveler information of interest from California, Oregon, Washington and Nevada (as available), including:

- Weather conditions (current and forecast),
- Planned and active closures (construction),
- Incidents,
- CCTV imagery,
- Changeable Message Sign (CMS) messages,
- Chain requirements,
- Route profiles/summits.
- Rest area locations,
- Scenic overviews and vistas,
- Other places of interest.

Local Travelers

Local travelers are those motorists whose trips are likely to be a shorter distance, typically between towns in a rural area. While their trips are characterized as local, the nature of such trips are similar to long distance trips. In a rural environment, particularly many of those found throughout the states of interest in this work, trips between towns can exceed 20 miles or more. In some cases routes cross mountain passes and traverse other roadway segments where weather conditions can vary greatly. Consequently, local travelers may need only a limited amount and range of information, such as weather, chain requirements (during the winter), CCTV imagery, planned and active closures, and incidents.

In general, this group is more familiar with the area and thus less concerned with route-planning. Rather, these travelers are more interested in learning from the system what they will face during their

trip, such as weather/roadway conditions construction zones, and road incidents. Such information could be used to determine whether to take a trip and/or whether an alternate route should be used. Weather would be a particular concern during winter months, as many of the short-distance trips may pass through varying terrain where roadway conditions can differ significantly over even a short distance. Providing near real-time, reliable information in such cases will enhance safety for local travelers.

To address the needs of this user group, the system will attempt to provide elements of traveler information of interest to local travelers (as available), including:

- Weather conditions (current and forecast),
- Planned and active closures (construction),
- Incidents,
- CCTV imagery,
- Changeable Message Sign (CMS) messages,
- Chain requirements,
- Route profiles/summits.

Goods Movement

The goods movement industry relies on truck drivers, company dispatchers and other parties who may provide drivers with routing for a particular shipment. This group is focused on the efficient routing of goods in transit, ensuring a timely delivery. Goods movement trips are typically long distance and multi-regional, although short trips may also be common, and timeliness is the primary concern.

While the goods movement industry is composed of primarily long-distance travelers (truck drivers), the information needs of this group differ from other long-distance travelers (vacationers, etc.). This group is primarily concerned with information necessary to avoid delays. Information is needed by this group both pre-trip and during the trip. Pre-trip information would inform route planning and help in understanding the general conditions that may be encountered (e.g., forecast weather, construction zones, etc.). In addition, the location of rest areas and inspection facilities/weigh stations would also be employed in planning a trip. Information obtained during the trip consists of the same information as that employed pre-trip (as well as current weather) to determine what conditions would be encountered along particular segments. Pre-trip information would be obtained by goods movement personnel through traditional means (Internet access from a personal computer or company workstation), while mobile/en-route information would be obtained via supplemental means (smartphone, web access at lodgings, wireless availability at restaurants and rest areas, etc.).

To address the needs of this user group, the system will provide elements of traveler information of interest to the goods movement industry (as available), including:

- Weather conditions (current and forecast),
- Planned and active closures (construction),
- Incidents,
- CCTV imagery,
- Chain requirements,

- Route profiles/summits,
- Changeable Message Sign (CMS) messages,
- General information:
    - Safety rest areas,
    - Commercial vehicle enforcement facilities,

DOT Personnel

While not the primary target of the traveler information provided by the system, DOT personnel, including management, operations and maintenance, may also be users of the website, particularly given its strong weather information component. These are the groups responsible for managing traffic and maintaining roadways. In this capacity, they also represent the foremost providers of data to support the system. Through their various capacities, this group provides timely data, such as Changeable Message Sign (CMS) messages, chain control status, etc., for the various electronic databases that will ultimately serve as inputs to the system. However, in the course of their responsibilities, this group may also employ the data provided by the system.

Anticipated data needs for these users are centered upon information that can assist with their typical responsibilities of management, operations, maintenance, etc. This information includes current and forecast weather, planned and active closures (construction), incidents, chain requirements (during winter) and CCTV imagery. All of these elements are items that are constantly changing and need to be continually tracked by transportation agencies. This user group is expected to access information from office workstations, as well as in the field via an aircard, smartphone, and other available means.

Data Elements and Components

Several unique data elements were available for inclusion and display in the system. Data streams and their sources recommended for use in the system are described in Table 2-1. Note that a more in-depth discussion of the specific data elements and their sources will be presented in the Requirements section.

Table 2-1. Data elements, description and sources

			Meets data needs of:			
Data Item	**Description**	**Source**	**Long Distance**	**Short Distance**	**Goods Movement**	**DOT Personnel**
Weather	Current and forcasted weather conditions	Clarus, National Weather Service, other	√	√	√	√
CMS messages	Text of currently displayed CMS messages	Caltrans, ODOT, Nevada N/A, WSDOT	√	√	√	√
CCTV images	Recent images from CCTV cameras	Caltrans, ODOT, NDOT N/A, WSDOT	√	√	√	√
Chain requirements	Current chain requirements for specific vehicles	Caltrans, ODOT, NDOT N/A, WSDOT	√	√	√	√
Planned and active closures	Current road construction, maintenance and similar activities	Caltrans, ODOT, NDOT N/A, WSDOT	√	√	√	√
Incidents	Currernt state police-reported crashes	California Highway Patrol, ODOT, Nevada N/A, WSDOT	√	√	√	√
Safety roadside rest areas	Location of highway rest areas	Caltrans , ODOT, Nevada N/A, WSDOT	√		√	
Features of Interest	Points of interest to travelers	Caltrans, Oregon N/A, Nevada N/A, WSDOT	√			
Commercial vehicle enforecement sites	Locations of commercial enforcement facilities	Caltrans, ODOT, Nevada N/A, WSDOT			√	
Summits	Location of summits along state highways	Caltrans, Oregon N/A, Nevada N/A, WSDOT	√	√	√	

Caltrans - California Department of Transportation
ODOT - Oregon Department of Transportation
NDOT - Nevada Department of Transportation
WSDOT - Washington Department of Transportation
N/A - Not Available

As the table indicates, data for the system was acquired from a variety of sources. Most information was acquired from state DOT sources, although some specific streams (weather, incidents), came from outside sources including *Clarus*, the National Weather Service, and state police departments. In most cases, a data element fulfilled the needs of multiple groups. In only limited cases was a specific data item targeted to the needs of only one group (features of interest and commercial enforcement sites). Overall, the data presented in the table somewhat extends beyond that traditionally offered by DOT traveler information websites.

Website Functions

The objective of the system was to move from an approach whereby the user/traveler is required to scan a website or multiple websites to identify traveler information of relevance to their trip. Instead, system users enter their origin and destination via a "trip planner" and are presented with all available information for that route. When initially entering the website, the user is presented with a region-wide viewing pane presenting current weather. They are also presented the capability to enter an origin and destination to obtain route specific information. For example, an origin might be Seattle and a destination may be Portland. Upon entering this information, the website accesses Google's algorithm to generate a route between these two points. Google Maps™ was used in development to simplify mapping and routing tasks.

Users are presented with a Google map containing icons representing all available information for the specified route for a selected feature of interest (ex. CCTV cameras). Users have the option to toggle specific data icons/streams on and off, viewing only the information of interest to them. For example, vacationers may only be interested in the location of scenic points or rest areas along their route. In such a case, they would specify that only the icons displaying this information be presented. This is the broad overview of how the system will function. More specific functions will be detailed in a separate requirements document. An overview of that document is presented in the following section.

Requirements

This section presents the requirements associated with the *Clarus* One-Stop Shop website. The *Systems Engineering Guidebook for ITS* divides requirements into seven categories: functional, performance, interface, data, non-functional, enabling, and constraints. These requirements together are used to define what the system should do, how well it is to perform, and under what conditions or constraints. However, some of these aspects do not apply to the website to be developed. As a result, only requirements pertaining to functional, performance, interface, data, and enabling aspects are included here. In defining the requirements for the website, the research team recognized that it is a challenge to specify requirements for a system which has previously been developed in a limited prototype capacity for a concept which is still in its infancy. Definitions used throughout this section are presented in

Table 2-2. Relevant Definitions

Term	Definition
Caltrans	California Department of Transportation
CMS	Changeable Message Sign
CCTV	Closed circuit television
DMS	Dynamic Message Sign
GIS	Geographic Information Systems
HAR	Highway Advisory Radio
ITS	Intelligent Transportation Systems
Interface	Abbreviated name for the client (HTML) interface that will display One Stop Shop data
NDOT	Nevada Department of Transportation
NWS	National Weather Service
ODOT	Oregon Department of Transportation
RWIS	Road Weather Information System
VMS	Variable Message Sign
WSDOT	Washington Department of Transportation

Functional Requirements

The functional requirements describe what the website is supposed to do. As described earlier, there are four groups of users who will use the website: local and long distance travelers, the goods movement industry, and DOT traffic management/operations/maintenance personnel. The function of the prototype website was to provide travelers in the Western States region – California, Oregon, Nevada and Washington – with comprehensive, real-time data that can be employed in planning their trip. This information would consist of both traditional information (routing, imagery, weather, etc.), as well as points of interest and other route-specific information (elevations, rest areas, etc.).

Data Set

The central feature of the One-Stop Shop is its service as a traveler information data source. As such, the first key set of functional requirements relates to the data that the website acquires, stores, manages and disseminates.

Weather Data

- *Clarus* ESS data shall be acquired directly from the Federal Highway Administration source (http://www.clarusinitiative.org/) for the study region.
- Weather data presently aggregated for California by the WeatherShare platform shall be acquired from the Western Transportation Institute directly to avoid redundant downloads.
- Supplemental weather data for the other study states shall be acquired, when available, from additional sources, such as the National Weather Service (NWS) - MADIS, and other entities such as Mesowest.

DMS Data

- The website shall acquire and disseminate all available DMS sign messages in the study region, provided spatial referencing is available to facilitate mapping (ex. route/milepost or geographic coordinates).

CCTV Images

- The website shall acquire and disseminate all available CCTV images in the study region, provided spatial referencing is available to facilitate mapping (ex. route/milepost or geographic coordinates).

Chain Requirements

- The website shall acquire and disseminate all available chain requirements in the study region, provided spatial referencing is available to facilitate mapping (ex. route/milepost or geographic coordinates). For the purposes of this document, chain requirements include not only requiring vehicles to have chains past a specific location, but also special winter storm traffic control (screening, truck holding, closures, etc. when available).
- Chain requirements shall include data for all available locations, including passes, if available.

Planned and Active Closures

- The website shall acquire and disseminate all available planned and active lane closures in the study region, provided spatial referencing is available to facilitate mapping (ex. route/milepost or geographic coordinates).

Incident Data

- The website shall acquire and disseminate incident data (accidents, emergency detours, etc.) in the study region, provided spatial referencing is available to facilitate mapping (ex. route/milepost or geographic coordinates).

Safety Roadside Rest Areas

- The location of safety roadside rest areas shall be acquired and disseminated in the study region, provided spatial referencing is available to facilitate mapping (ex. route/milepost or geographic coordinates).

Features of Interest

- The location of vista points and points of interest shall be acquired and disseminated in the study region, provided spatial referencing is available to facilitate mapping (ex. route/milepost or geographic coordinates).

Commercial Vehicle Enforcement Facilities

- The location of commercial vehicle enforcement facilities shall be acquired and disseminated in the study region, provided spatial referencing is available to facilitate mapping (ex. route/milepost or geographic coordinates).

Summit Locations

- The location of state highway system summits shall be acquired and disseminated in the study region, provided spatial referencing is available to facilitate mapping (ex. route/milepost or geographic coordinates).

Additional Data Elements

- Additional data elements may be added to the website either during the development of the prototype or at a future date if deemed beneficial.

Future Data

- The website shall be designed such that it can incorporate additional data in the future, such as Traffic Monitoring Station (TMS) data.

User Functions

As a prototype which is focused on the provision of traveler information, the primary users of the Western States One-Stop Shop will be local and long distance travelers planning a trip. Other user groups discussed include goods movement and transportation agency personnel.

- The website shall be map based with textual elements as needed and display the information of the data set for study region. The website shall present an overview map for the entire region prior to user entry of a trip origin and destination.
- The website shall provide a mechanism to the user to enter an origin and destination for their trip.
- When selected, an icon shall display concise textual information regarding the selected item in a balloon.

Functional Requirements

Performance requirements refer to measurable system capabilities. This section summarizes the updating and delivery frequency requirements for the website.

Updating and Delivery Frequency

- The website shall check for new data to pull in from the data sources at periodic intervals.
- The data source providers shall maintain their traditional updating frequencies for their respective data feeds (i.e. the website shall not require changes to current procedures on the part of data providers).
- Data elements that are not dynamic (ex. rest area locations, summits, etc.) will not require interval checks for data updates.
- The website shall pull data from specified sources; no data source/provider shall push data to the website.
- The website shall only serve as a dissemination platform for travel information, not a data entry mechanism.

Quality Control

- The website shall not serve as a quality control monitor for the data supplied by agencies.
- Quality control activities with respect to the website shall consist solely of checks made to ensure fixed data sources (CCTV, chain control, rest areas, etc.) are displayed in the correct geographic location.

Website Requirements

This section in a typical requirements document discusses a system's hardware and software interfaces; i.e. how a system is supposed to interact with other systems.

General

- The website shall be available via commonly available web browser software running on a desktop or laptop PC platform.
- The website shall be housed on a server running a widely used operating system, database and web service.
- The website shall pull in data from specific sources and provide that data to user groups via web-based protocols.
- The website shall employ a database to support queries and general data storage.

Data Format and Standards

- The website shall be capable of reading all data formats of the supplying agencies.

Interface Display

- The website display shall be map-based.
- The website shall only display information contained within the view of the Google-generated route as specified by the user's origin and destination points.
- The website display shall consist of an initial viewing pane that presents the study region overall.

Control

- The website shall require some interaction on the part of the user (i.e. enter the origin and destination points for a trip and/or dragging the Google-generated route to a different path if desired).
- The website shall allow users to select specific layers of information of interest to display.
- Each layer may be toggled on and off by the user.

Enabling Requirements

Requirements in this section relate to aspects of the website whose functions enable it to properly fulfill its purpose.

Software

- The website shall require no specialized, third-party software to acquire, reformat or disseminate the available information previously detailed.

Installation Design

- The website shall operate in a standard web browser and be designed such that access may be accomplished by the user via a website link.

Website Server

- The initial location of the website server shall be the Western Transportation Institute.
- The website shall be maintained by the Western Transportation Institute during the course of this project.
- The future of the website maintenance following the conclusion of this project shall be discussed by the researchers, the sponsor and the participating states as development activities progress.

Documentation

- Brief documentation pertaining to the development and coding of the website shall be compiled by the Western Transportation Institute as part of the project final report.
- The website shall include a “Help” link to assist the user through use of the website.

Summary

This chapter has provided a high-level overview of the Concept of Operations and Requirements documents that were established to guide the development of the One-Stop Shop website. The Concept of Operations established that the One-Stop Shop website would allow users to do. The requirements translated the system concept/concept of operations into a series of statements describing what the system shall do to accomplish its intended function. The information provided was a condensed version of the full documents that were developed and in order to present the reader with an overview of the different aspects that were considered in developing the website. The information selected for inclusion in this chapter illustrates the major instructions and specifications that were laid out to guide website development.

Chapter 3 System Design and Development

A high-level system design document was created in conjunction with the development of the Western States One-Stop Shop as a separate, formal deliverable. The purpose of the design document was to convey, at a high-level, the design decisions and issues that were made and addressed to implement this system. That document was not intended to be a formal, standards-based design document. Instead, the approach was taken to document design decisions and commentary directly inline with requirements that were developed and approved previously within this project. This approach was taken to enable stakeholders to trace design decisions directly to the requirements that they address. Screenshots of the (prospective) user interface were used where appropriate to demonstrate the design. Similarly, screenshots are used within this section to document the final system design.

Hardware and Software Platform

The system operates on a standard (Debian) Linux platform running an Apache web server, MySQL database and scripting languages including Perl, PHP and Python. At present, data storage is accomplished via flat file storage with database usage deferred until subsequent revisions are made that are outside the scope of this project.

A standard hardware platform was used. The system was designed, however, to support prospective migration to another platform, perhaps housed by a service provider or even offered as part of a cloud-based service such as the Amazon Elastic Computer Cloud (EC2) or similar service. A Linux-based software platform facilitates this. An existing server used for prior, related projects was used to host this project. It has the following configuration: Dell PowerEdge 2900 III server, with Dual Quad Core Intel® Xeon®X5450 3.0GHz, 300 GB x 2 RAID hard drive, and 16 GB memory.

Google Analytics™ has been used to record and track system usage including data selection, regions viewed, etc. so that the project team could analyze system usage. Events were defined and implemented to facilitate this tracking via Google Analytics™.

User Interface

The website is delivered via a standard HTML interface, including dynamic functionality via Dynamic HTML, Javascript and general AJAX (asynchronous JavaScript and XML). It is accessible via current and recent versions of Internet Explorer™, Firefox™, Safari™ and Chrome™. Google Maps™ is used for the primary website interface display, via the Google Maps™ Javascript API, version 3.0.

Custom controls are provided for data layer selection, timeframe selection (where applicable), help, access to the associated survey, legend for the selected layer, and route planner functionality. See Figure 3-1.

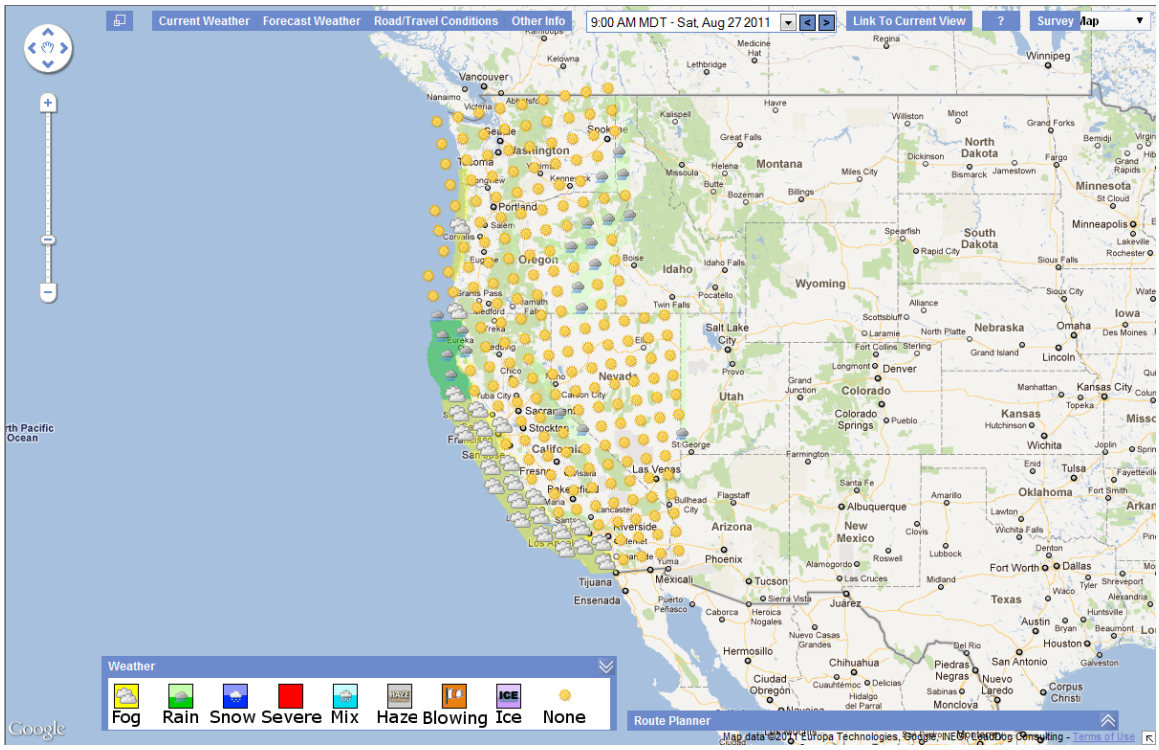

Figure 3-1. Western States One-Stop Shop User Interface from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD)

Current Weather

Sensor readings from *Clarus* ESS (RWIS) Stations are shown in conjunction with readings from MADIS and Mesowest to present current (recent) conditions from sensors. Separate layers are presented for air temperature, relative humidity, 1 hour cumulative precipitation, 24 hour cumulative precipitation and wind. A separate layer is included showing RWIS sites reporting recent conditions, as well as a layer that presents a raster of estimated cumulative precipitation (AHPS 24 hr Precip.) over the region. Conditions reported within the past 90 minutes are considered current for all except the AHPS 24 hr Precipitation layer, for which the most recent report within the past 24 hours is shown. All current weather layers are available for the entire four state region. See Figure 3-2.

Figure 3-2. Current Weather Menu from the One Stop Shop Google Maps™ Interface

Air Temperature

Recent air temperature readings are presented using colored, circular icons containing numeric values. See Figure 3-3.

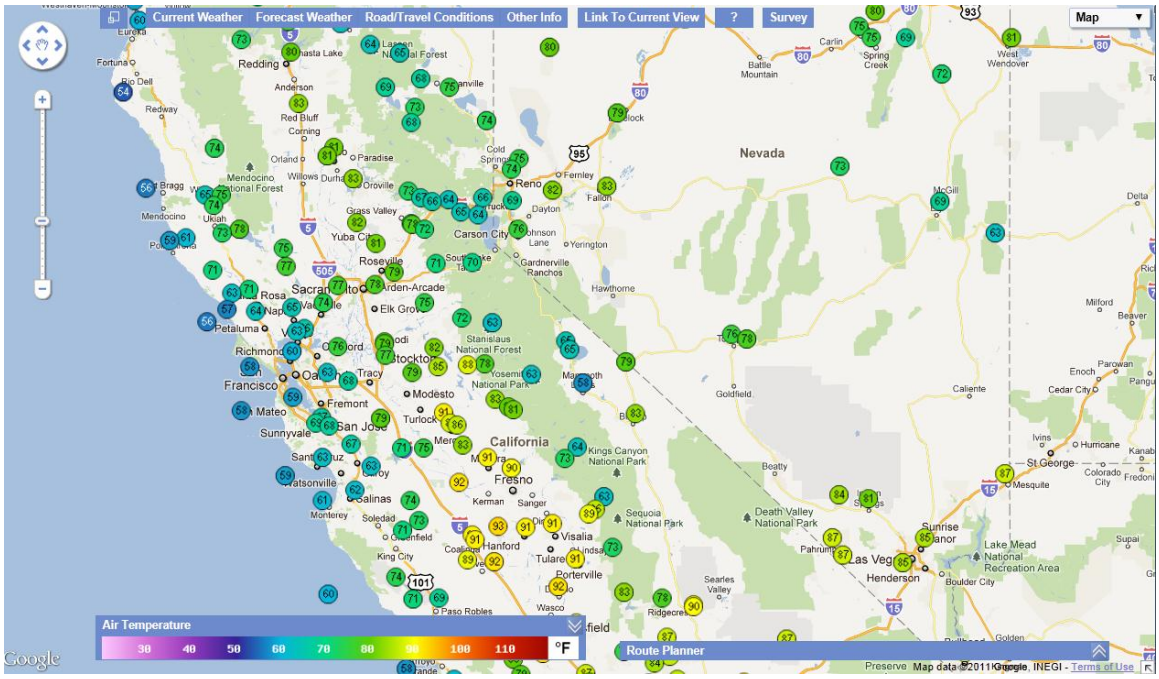

Figure 3-3. Current Air Temperature from the One Stop Shop Google Maps™ Interface (Data Source: MADIS, Mesowest, *Clarus*)

Further site detail can be viewed by clicking on an icon, including other sensor readings from that site. See Figure 3-4.

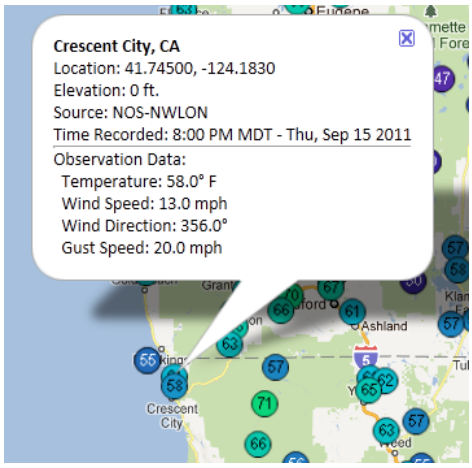

Figure 3-4. Station Detail from the One Stop Shop Google Maps™ Interface (Data Source: MADIS, Mesowest, *Clarus*)

Relative Humidity

Recent air humidity readings are presented using colored, circular icons containing numeric values. See Figure 3-5.

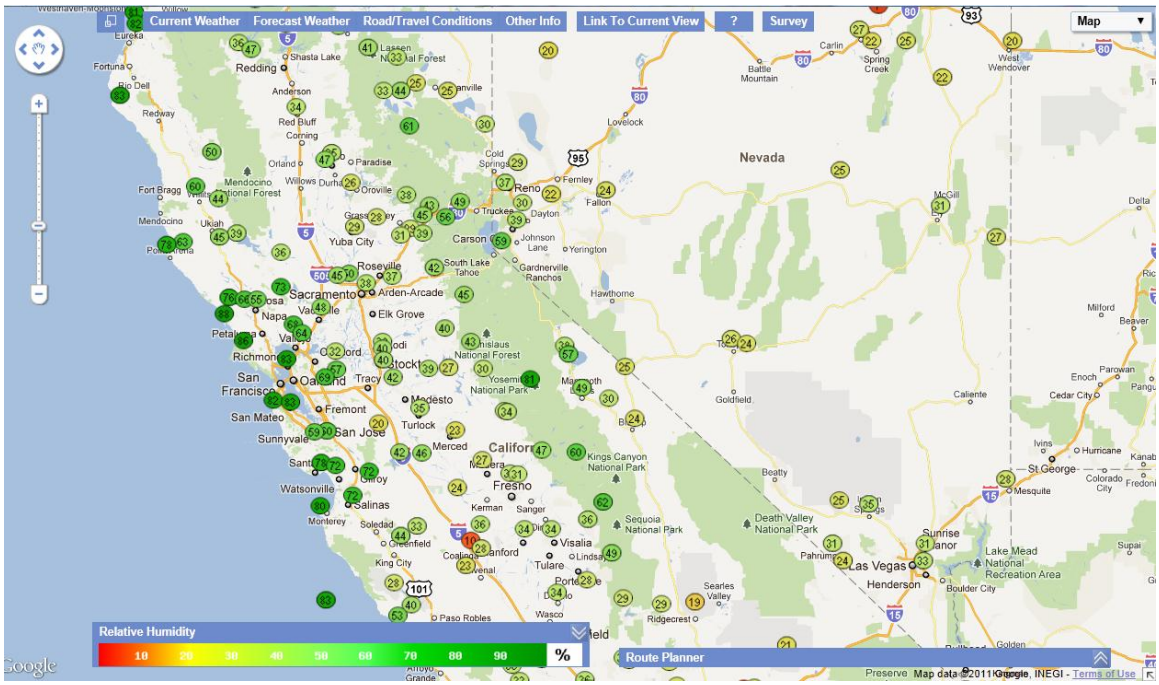

Figure 3-5. Current Humidity from the One Stop Shop Google Maps™ Interface (Data Source: MADIS, Mesowest, *Clarus*)

Further site detail can be viewed by clicking on an icon, including other sensor readings from that site. See Figure 3-6.

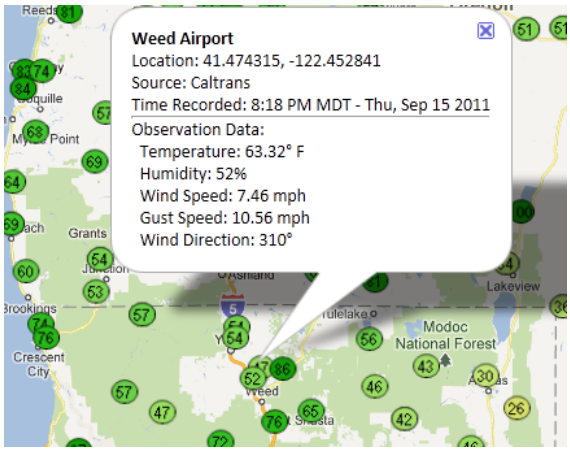

Figure 3-6. Station Detail from the One Stop Shop Google Maps™ Interface(Data Source: MADIS, Mesowest, *Clarus*)

1 Hour Precipitation

Recent 1 hour cumulative precipitation readings are presented using colored, circular icons containing numeric values. See Figure 3-7.

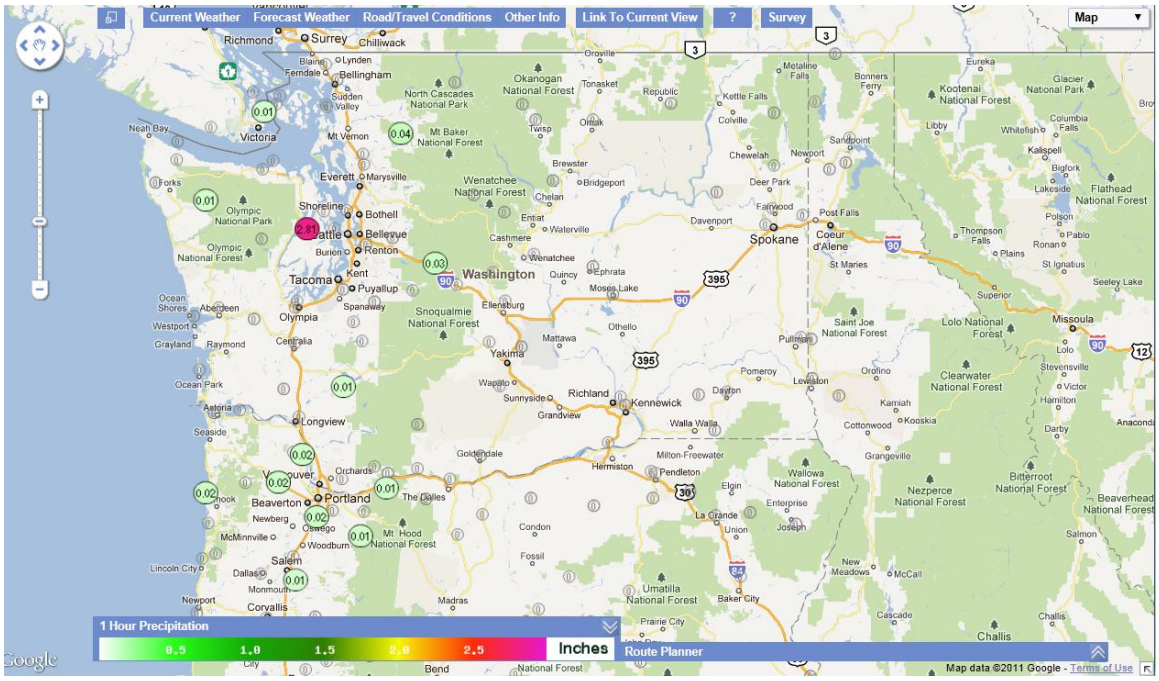

Figure 3-7. 1 Hour Precipitation from the One Stop Shop Google Maps™ Interface (Data Source: MADIS, Mesowest, *Clarus*)

Further site detail can be viewed by clicking on an icon, including other sensor readings from that site. See Figure 3-8.

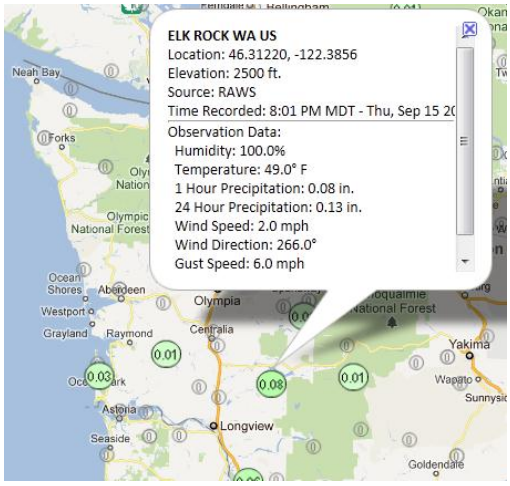

Figure 3-8. Station Detail from the One Stop Shop Google Maps™ Interface (Data Source: MADIS, Mesowest, *Clarus*)

24 Hour Precipitation

Recent 24 hour cumulative precipitation readings are presented using colored, circular icons containing numeric values. See Figure 3-9.

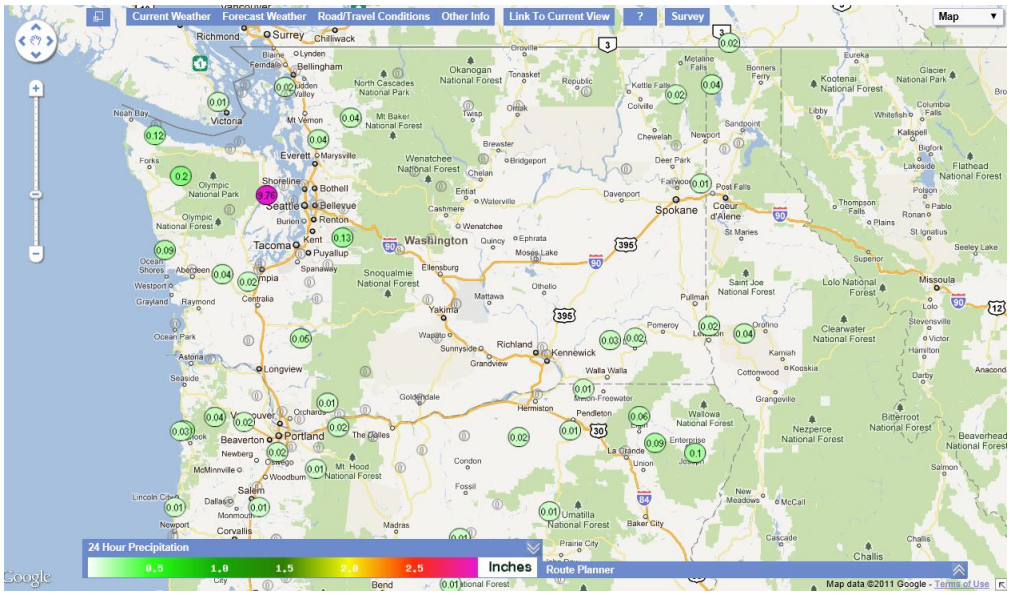

Figure 3-9. 24 Hour Precipitation from the One Stop Shop Google Maps™ Interface (Data Source: MADIS, Mesowest, *Clarus*)

Further site detail can be viewed by clicking on an icon, including other sensor readings from that site. See Figure 3-10.

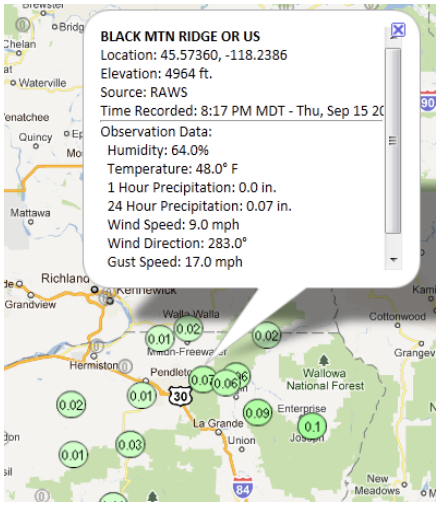

Figure 3-10. Station Detail from the One Stop Shop Google Maps™ Interface (Data Source: MADIS, Mesowest, *Clarus*)

AHPS 24 hr Precip.

A raster from the National Weather Service Advanced Hydrologic Prediction Service covering the four state region and showing estimated prior 24-hour precipitation data is retrieved from the National Weather Service and presented as a combination of a raster background and colored, circular icons with numeric values within. The raster is fully transparent over areas for which estimated prior precipitation is zero. Smaller icons indicating zero precipitation are used for the same. Non-zero values are presented using colored, circular icons containing numeric values. The end time for the given 24 hour period is shown in the legend. See Figure 3-11.

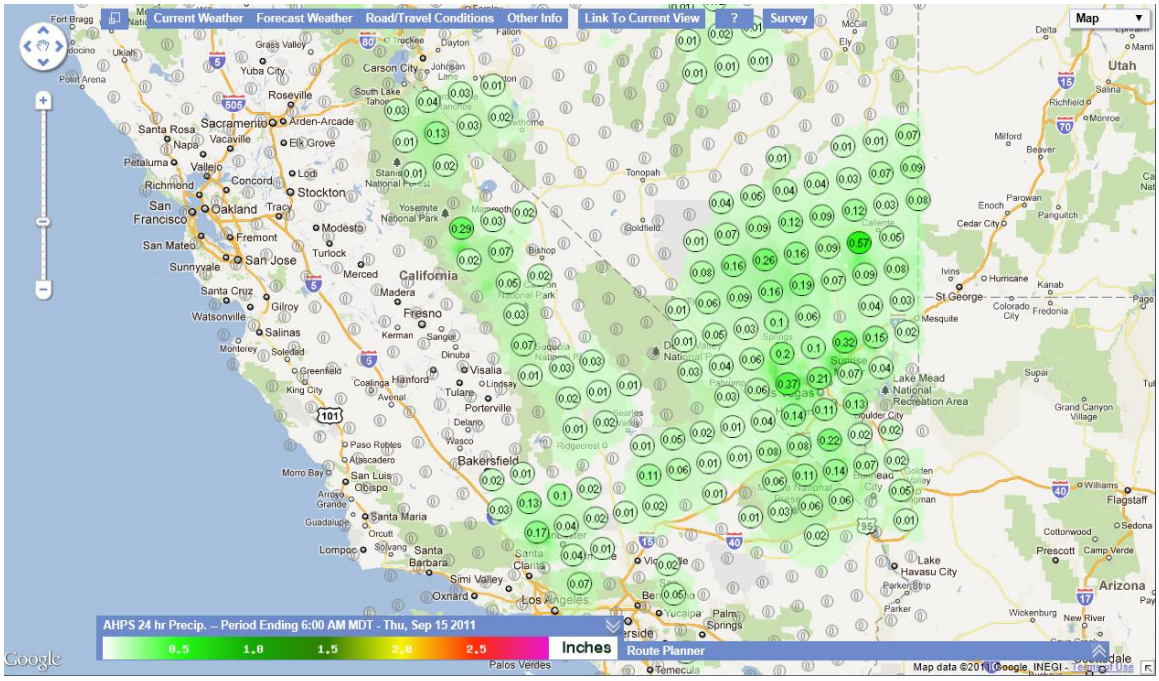

Figure 3-11. National Weather Service Advanced Hydrologic Prediction Service (AHPS) 24 hr Precipitation from the One Stop Shop Google Maps™ Interface (Data Source: NWS AHPS)

Wind

Recent wind readings are presented using colored icons (arrows) to represent both magnitude and direction. See Figure 3-12.

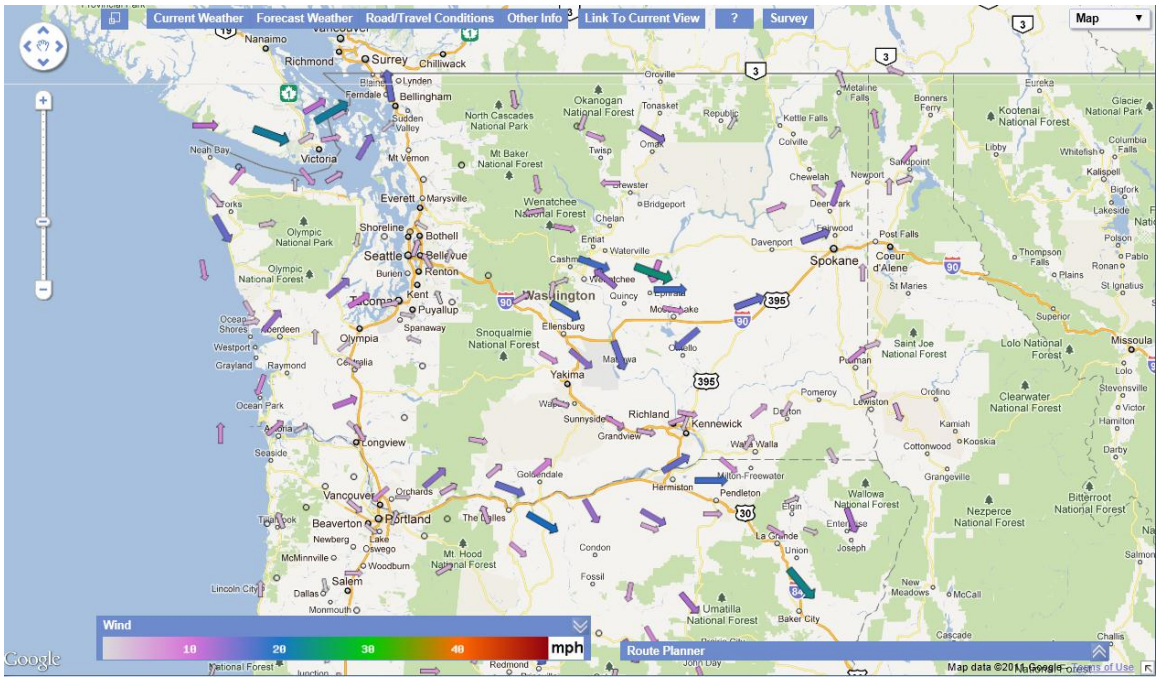

Figure 3-12. Current Wind from the One Stop Shop Google Maps™ Interface (Data Source: MADIS, Mesowest, *Clarus*)

Further site detail can be viewed by clicking on an icon, including other sensor readings from that site. See Figure 3-13.

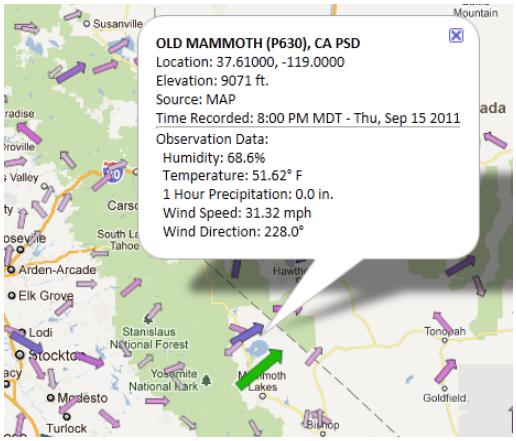

Figure 3-13. Station Detail from the One Stop Shop Google Maps™ Interface(Data Source: MADIS, Mesowest, *Clarus*)

Clarus Stations

Clarus ESS data is retrieved from the *Clarus* System at http://www.clarus-system.com/ via a subscription that is polled every 15 minutes. ESS (RWIS) sites are shown for only those sites having data retrieved in the most recent feed. See Figure 3-14.

Figure 3-14. *Clarus* Stations from the One Stop Shop Google Maps™ Interface (Data Source: *Clarus*)

Sensor types vary by site and state. To see a display of the most recent sensor readings from a site, users may click on the RWIS icon representing that site. See Figure 3-15 and Figure 3-16.

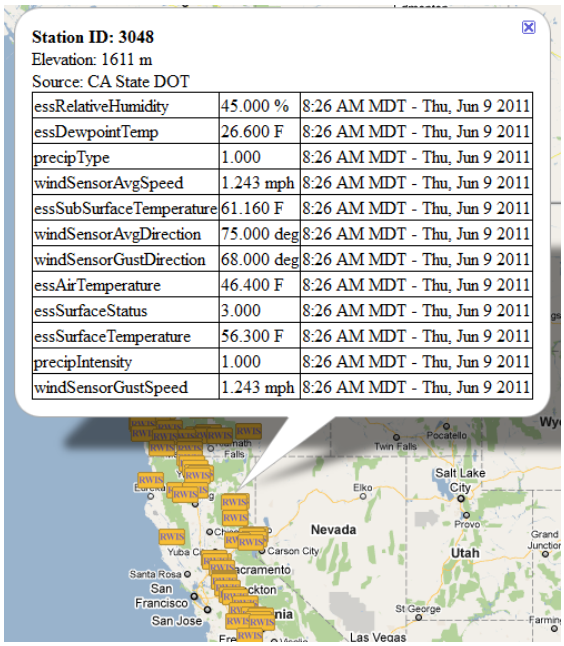

Figure 3-15. *Clarus* Station Display for a Caltrans RWIS Site from the One Stop Shop Google Maps™ Interface (Data Source: *Clarus*)

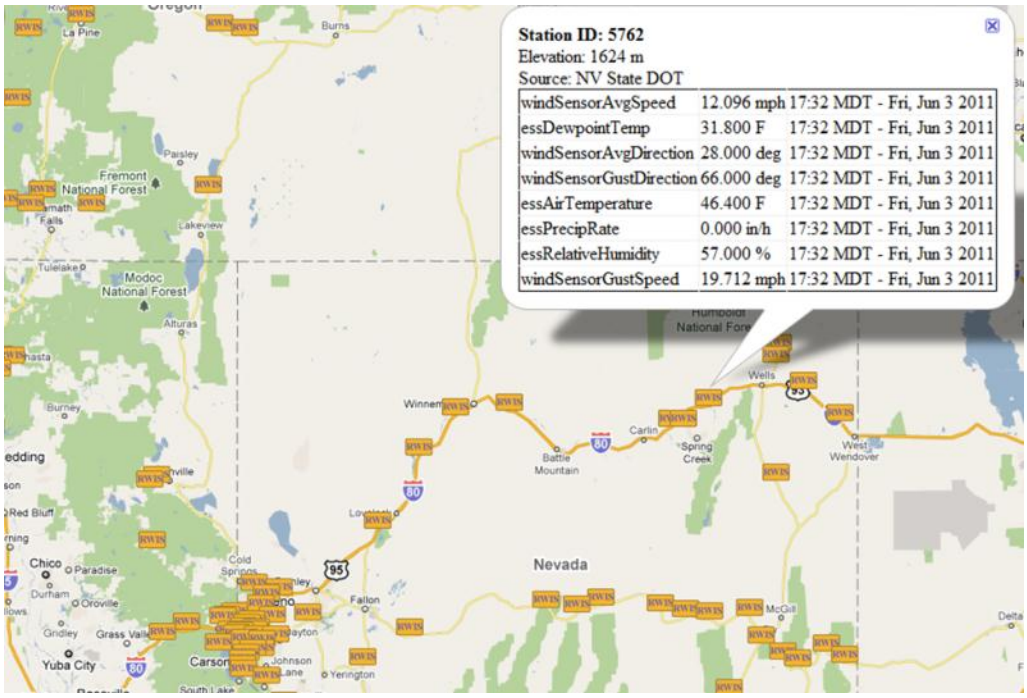

Figure 3-16. *Clarus* Station Display for a Nevada RWIS Site from the One Stop Shop Google Maps™ Interface (Data Source: *Clarus*)

RWIS sites are complemented in the system by other weather stations in proximity. For instance, there are six WSDOT RWIS sites in the Olympic Peninsula. See Figure 3-17.

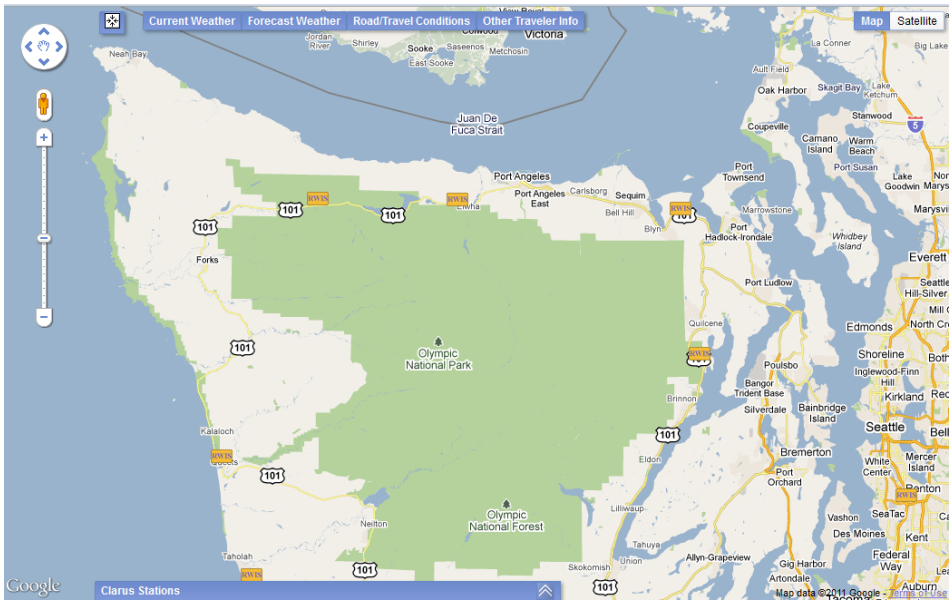

Figure 3-17. RWIS Stations on Washington's Olympic Peninsula from the One Stop Shop Google Maps™ Interface (Data Source: *Clarus*)

These sites are complemented by several dozen additional weather station sites in the same area. See Figure 3-18.

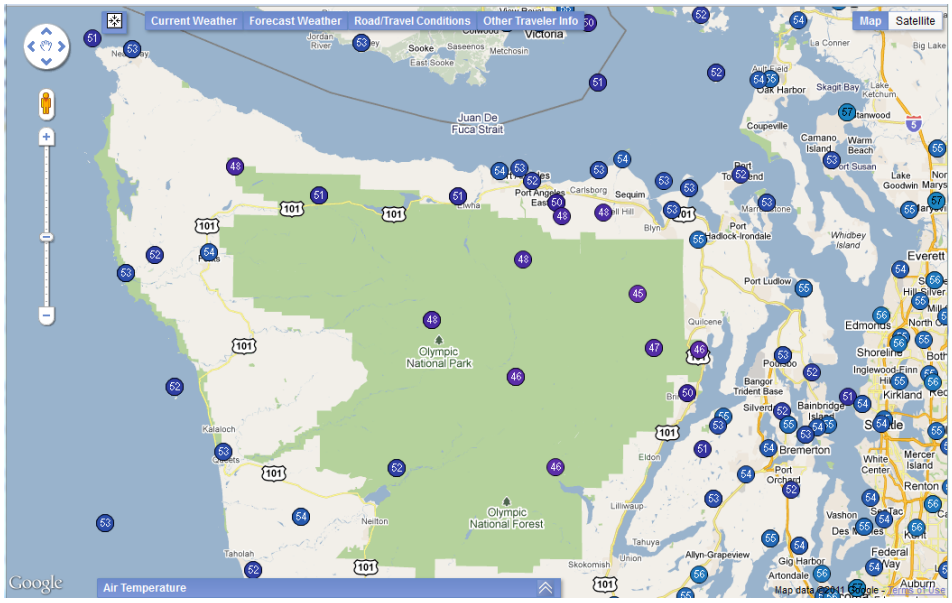

Figure 3-18. Additional Weather Stations on Washington's Olympic Peninsula (includes RWIS) from the One Stop Shop Google Maps™ Interface (Data Source: MADIS, Mesowest, *Clarus*)

Readings from the RWIS sensors are also displayed in corresponding layers. For instance, air temperature readings from RWIS sites are shown in conjunction with air temperature readings from non-RWIS sites in the current air temperature layer. See Figure 3-19.

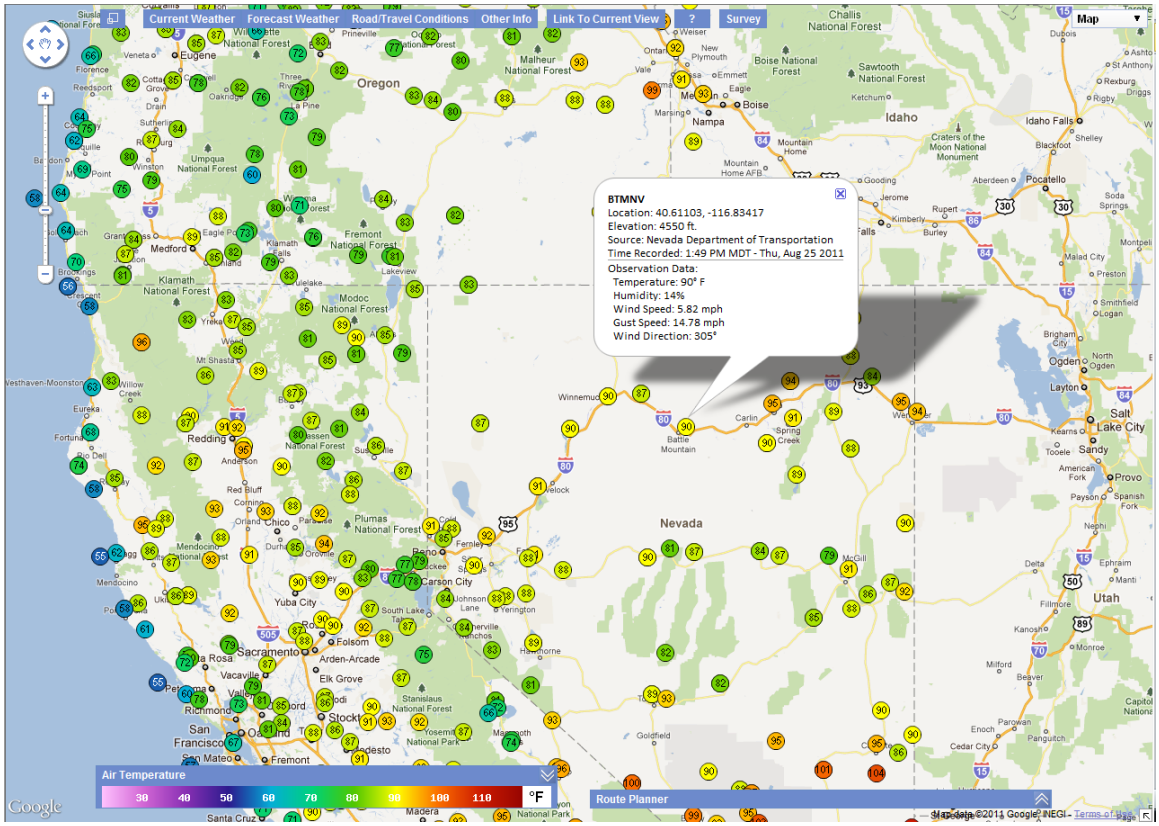

Figure 3-19. RWIS Station Report Shown in Current Conditions Temperature Display from the One Stop Shop Google Maps™ Interface (Data Source: MADIS, Mesowest, *Clarus*)

Forecast Weather

Rasters from the National Weather Service National Digital Forecast Database (NDFD) covering the four state region and showing forecast conditions are retrieved from the National Weather Service and presented using a combination of rasters and icons. Forecasts are included for each layer for up to three days from present time. The following forecast layers are included: air temperature, wind speed, wind gust speed, humidity, sky cover, 12-hour chance of precipitation, 6-hour precipitation, snow amount, and general weather. See Figure 3-20.

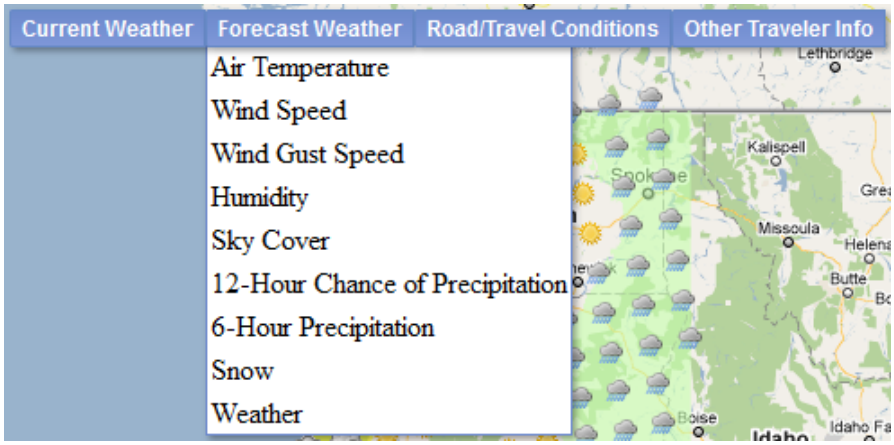

Figure 3-20. Forecast Weather Menu from the One Stop Shop Google Maps™ Interface

Air Temperature

Air temperature forecasts are presented using colored, circular icons containing numeric values. The time period for the forecast can be changed using the date/time dropbox to show forecasts up to three days from present. See Figure 3-21.

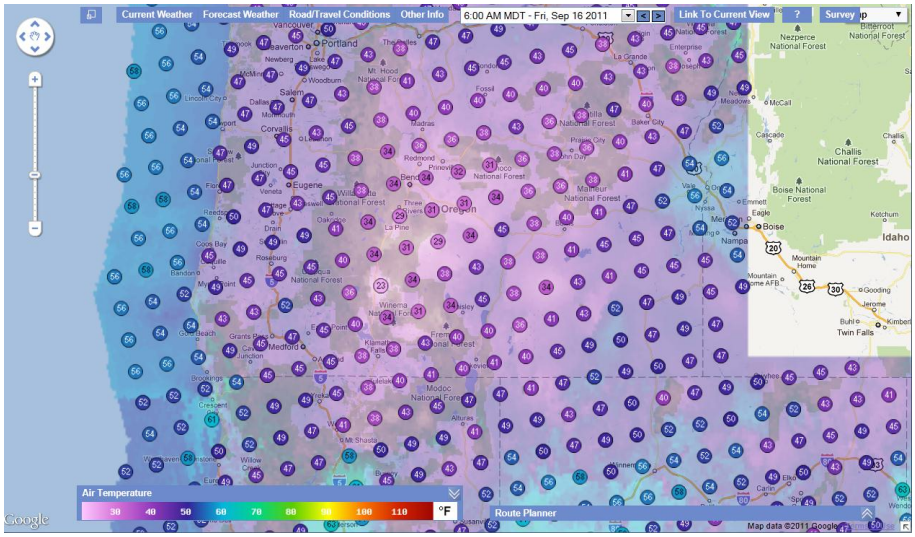

Figure 3-21. Forecast Air Temperature from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD)

Wind Speed

Wind speed forecasts are presented using colored icons (arrows) to represent both magnitude and direction. The time period for the forecast can be changed using the date/time dropbox to show forecasts up to three days from present. See Figure 3-22.

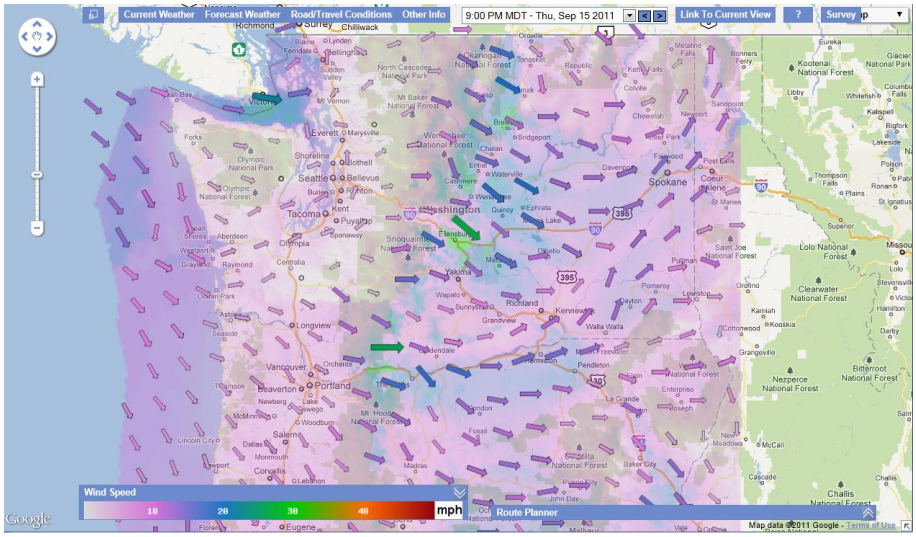

Figure 3-22. Forecast Wind Speed from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD)

Wind Gust Speed

Wind gust speed forecasts are presented using colored icons (arrows) to represent both magnitude and direction. The time period for the forecast can be changed using the date/time dropbox to show forecasts up to three days from present. See Figure 3-23.

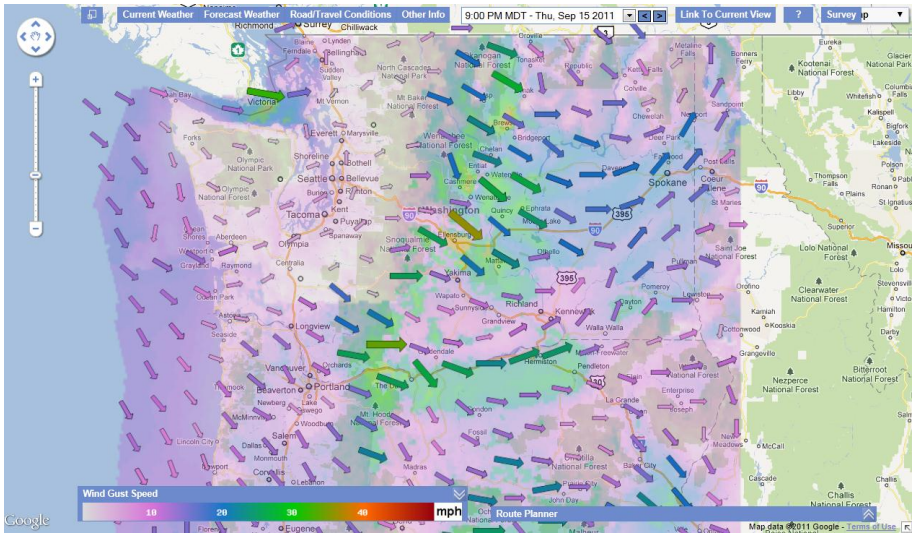

Figure 3-23. Forecast Wind Gust Speed from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD)

Humidity

Humidity forecasts are presented using colored, circular icons containing numeric values. The time period for the forecast can be changed using the date/time dropbox to show forecasts up to three days from present. See Figure 3-24.

Figure 3-24. Forecast Humidity from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD)

Sky Cover

Sky cover forecasts are presented using colored, circular icons containing numeric values indicating percent sky cover. The time period for the forecast can be changed using the date/time dropbox to show forecasts up to three days from present. See Figure 3-25.

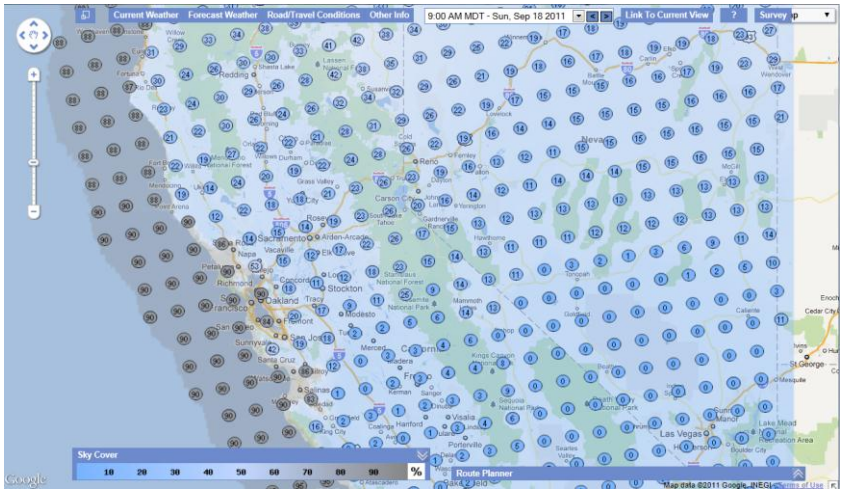

Figure 3-25. Forecast Sky Cover from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD)

12-Hour Chance of Precipitation

12-hour chance of precipitation forecasts are presented using colored, circular icons containing numeric values indicating the percent chance of precipitation over the selected 12 hour time period. The time period for the forecast can be changed using the date/time dropbox to show forecasts up to three days from present. See Figure 3-26.

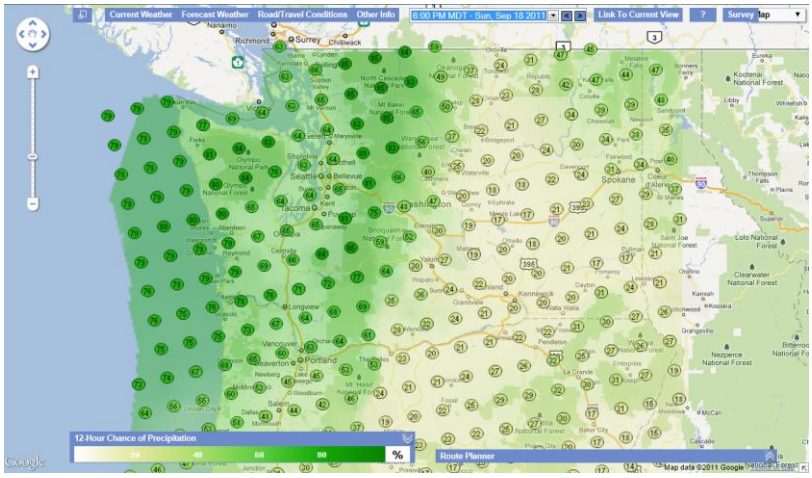

Figure 3-26. Forecast 12-Hour Chance of Precipitation from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD)

6-Hour Precipitation

6-hour precipitation forecasts are presented using colored, circular icons containing numeric values indicating the forecast amount of precipitation in inches. The time period for the forecast can be changed using the date/time dropbox to show forecasts up to three days from present. See Figure 3-27.

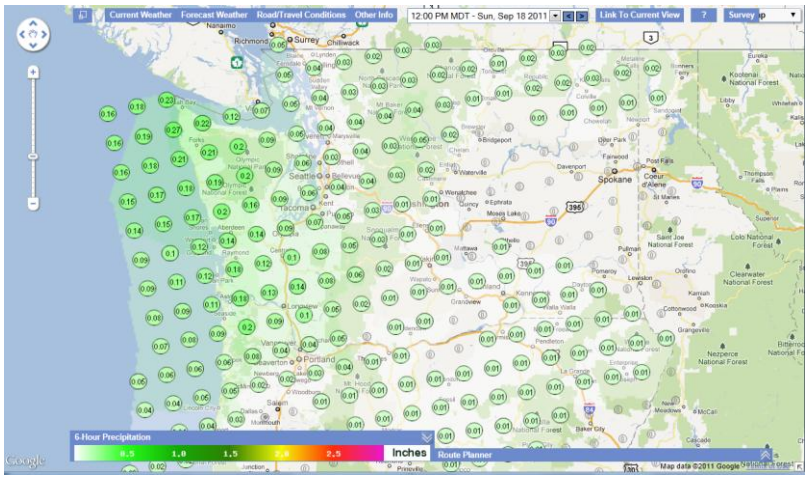

Figure 3-27. Forecast 6-Hour Precipitation Amount from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD)

Snow

Snow amount forecasts are presented using colored, circular icons containing numeric values indicating the forecast amount of snow in inches. The time period for the forecast can be changed using the date/time dropbox to show forecasts up to two days from present. See Figure 3-28 and Figure 3-29.

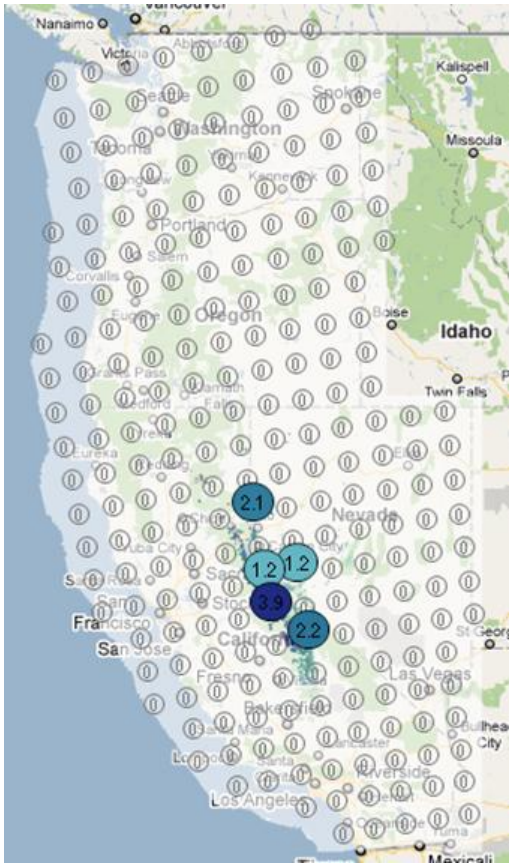

Figure 3-28. Forecast Snow Amount from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD)

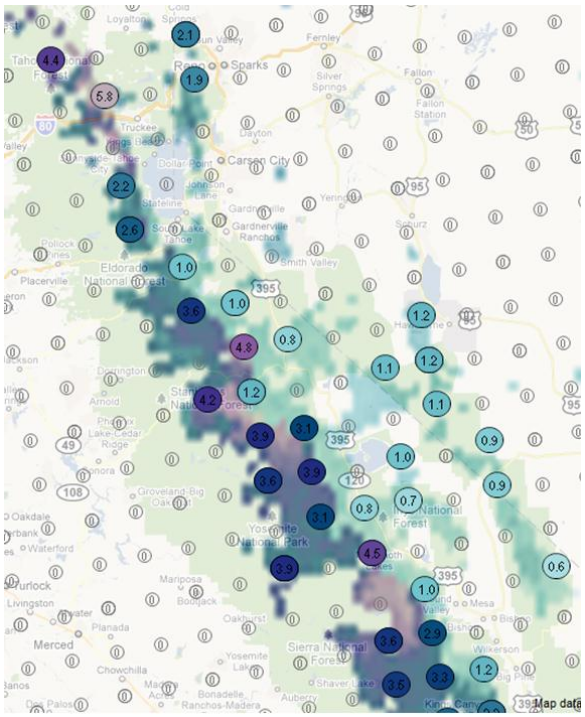

Figure 3-29. Forecast Snow Amount Detail from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD)

Weather

General weather forecasts are presented using thematic icons representing weather conditions including fog, rain, snow, severe weather, mixed weather, haze, blowing, ice and none (sunny). The time period for the forecast can be changed using the date/time dropbox to show forecasts up to three days from present. See Figure 3-30.

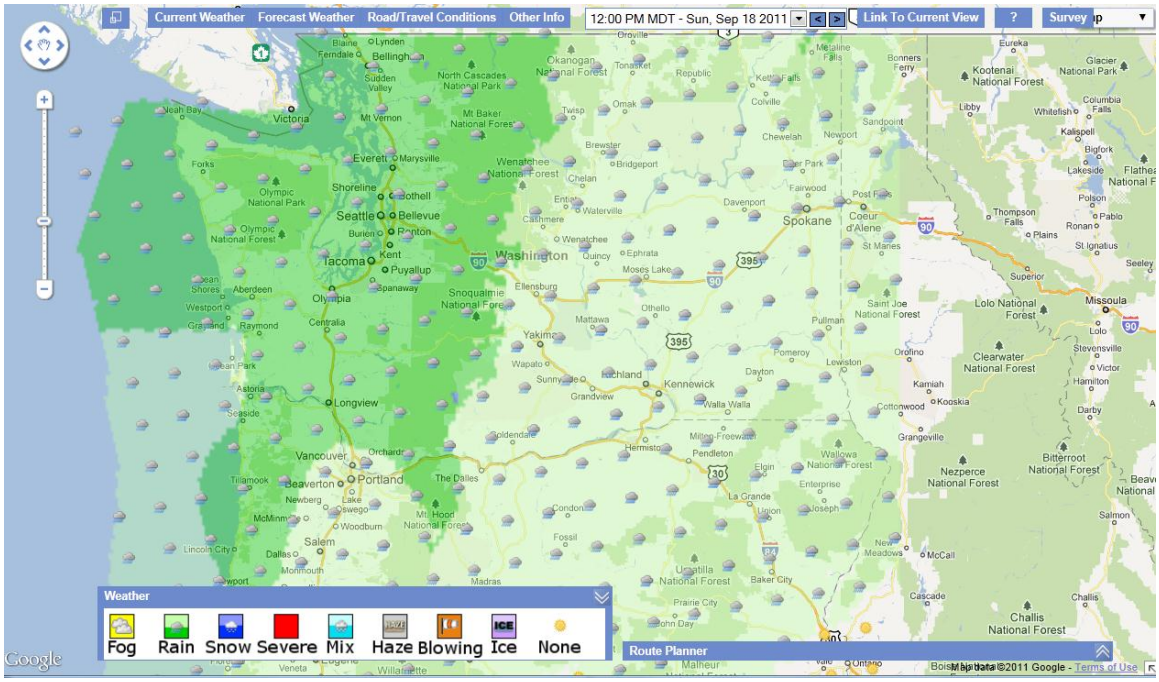

Figure 3-30. Forecast Weather from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD)

Further forecast detail can be viewed by clicking on an icon. See Figure 3-31 and Figure 3-32.

Figure 3-31. Forecast Weather Detail from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD)

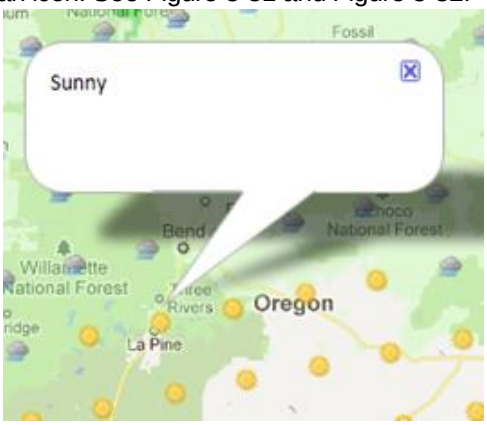

Figure 3-32. Forecast Weather Detail from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD)

Road/Travel Conditions

Road/Travel conditions include chain requirements, road information, incidents, changeable message sign messages and CCTV images. See Figure 3-33.

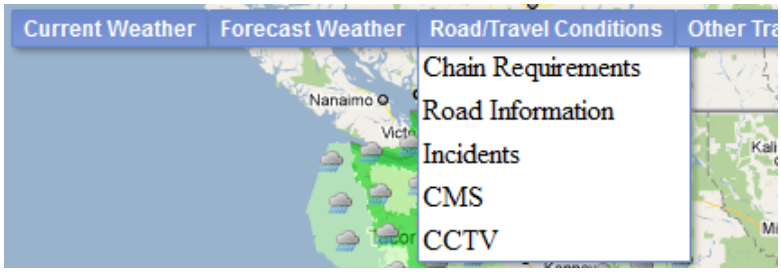

Figure 3-33. Road/Travel Conditions Menu from the One Stop Shop Google Maps™ Interface

Chain Requirements

Chain requirements are represented with icons on the map. Clicking on a chain requirement icon displays the corresponding message. The location and time of the message are displayed with other information that varies from state to state. See Figure 3-34.

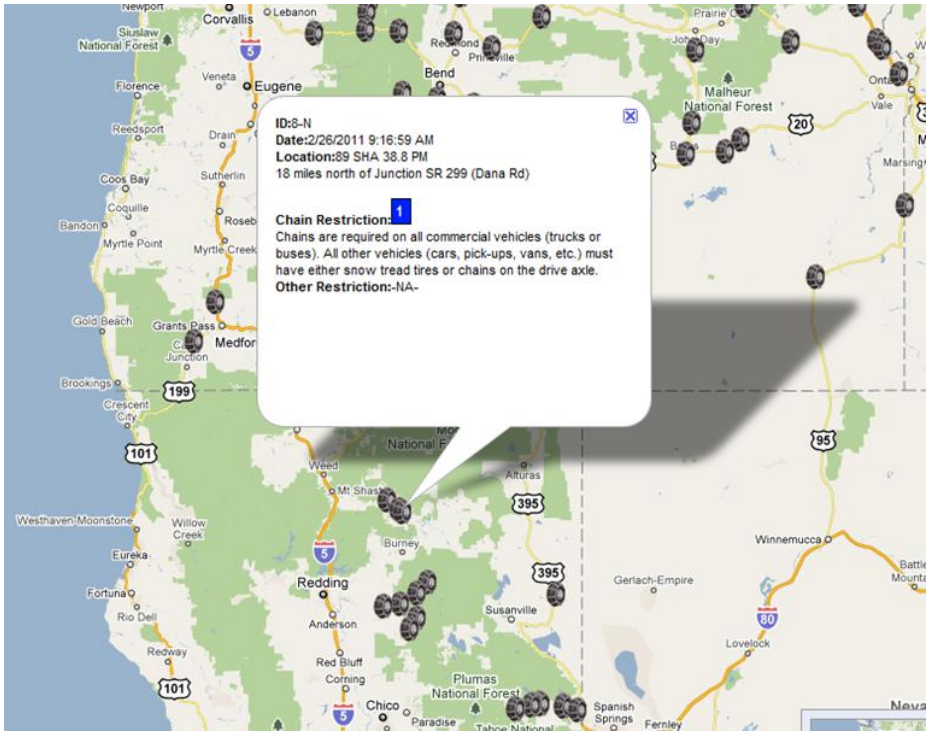

Figure 3-34. Chain Requirements from the One Stop Shop Google Maps™ Interface (Data Source: Caltrans, ODOT, WSDOT)

Road Information

The road information includes general information messages, commercial vehicle information and construction and maintenance information. These are designated by different icons. See Figure 3-35.

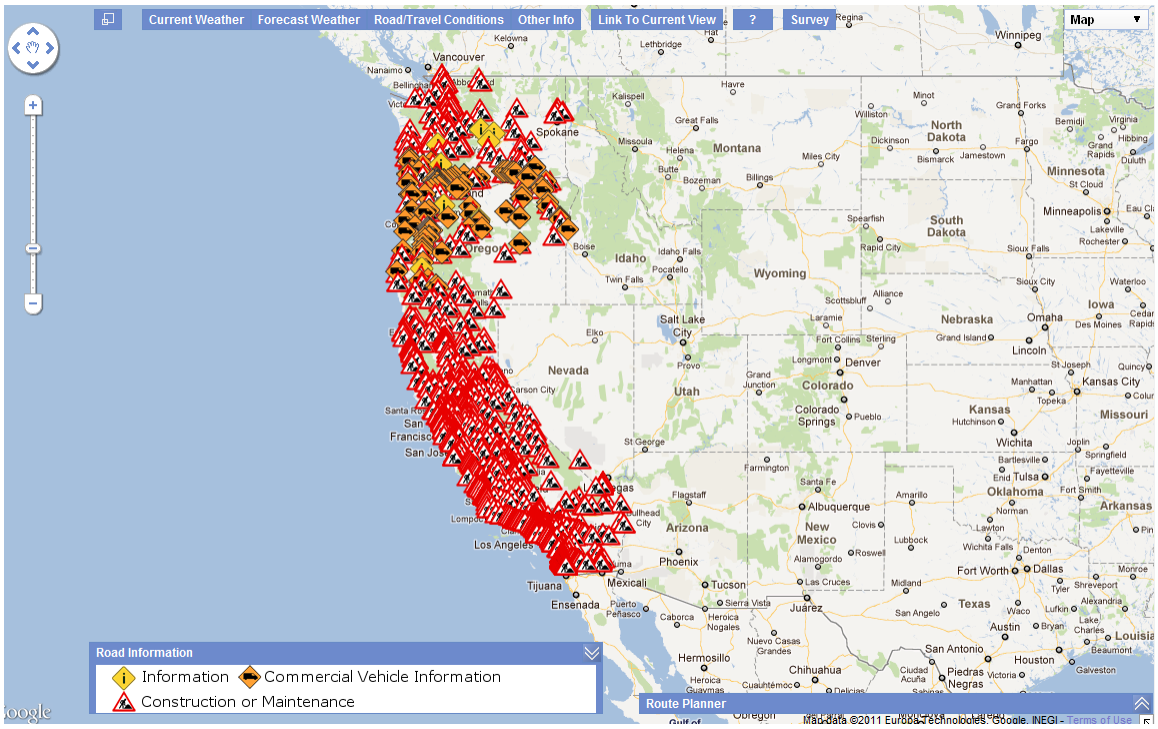

Figure 3-35. Road Information Layer from the One Stop Shop Google Maps™ Interface (Data Source: Caltrans, ODOT, WSDOT)

Many different types of messages are shown in this layer, and usage and format may vary by state. See Figure 3-36 through Figure 3-39.

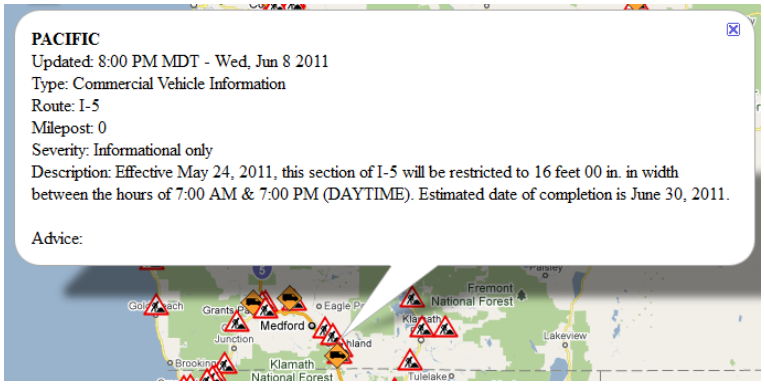

Figure 3-36. Width Restriction Along I-5 in Oregon from the One Stop Shop Google Maps™ Interface (Data Source: ODOT)

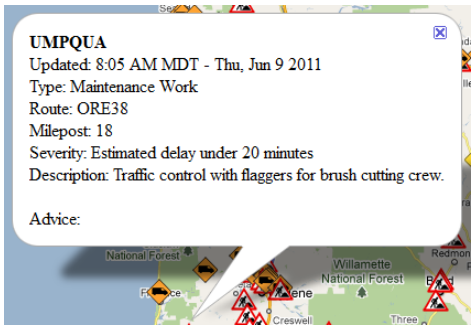

Figure 3-37. Maintenance Delay Information from ODOT for Oregon 38 from the One Stop Shop Google Maps™ Interface (Data Source: ODOT)

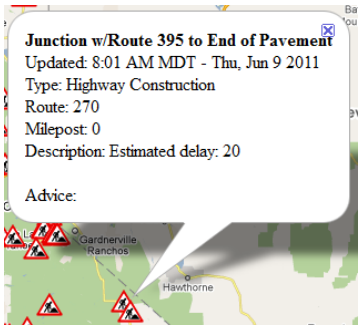

Figure 3-38. Construction Delay in Southeastern California on SR-270 from the One Stop Shop Google Maps™ Interface (Data Source: Caltrans)

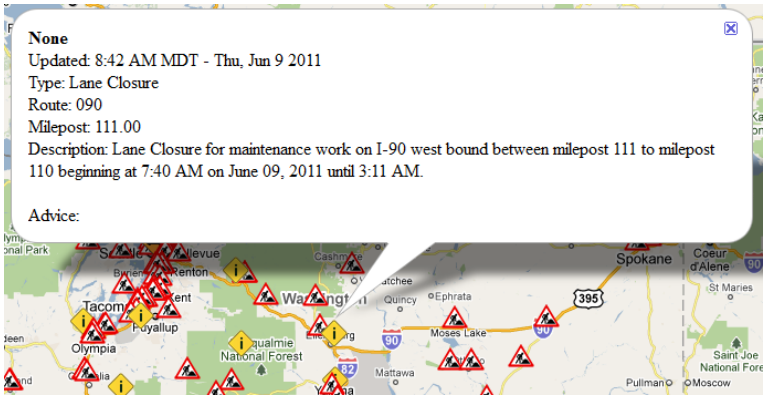

Figure 3-39. Lane Closure Message from WSDOT for I-90 from the One Stop Shop Google Maps™ Interface (Data Source: WSDOT)

Incidents

Incidents are represented with icons on the map. Clicking on an incident icon displays the corresponding incident description. The location and time of the incident are displayed with other information that varies from state to state. See Figure 3-40.

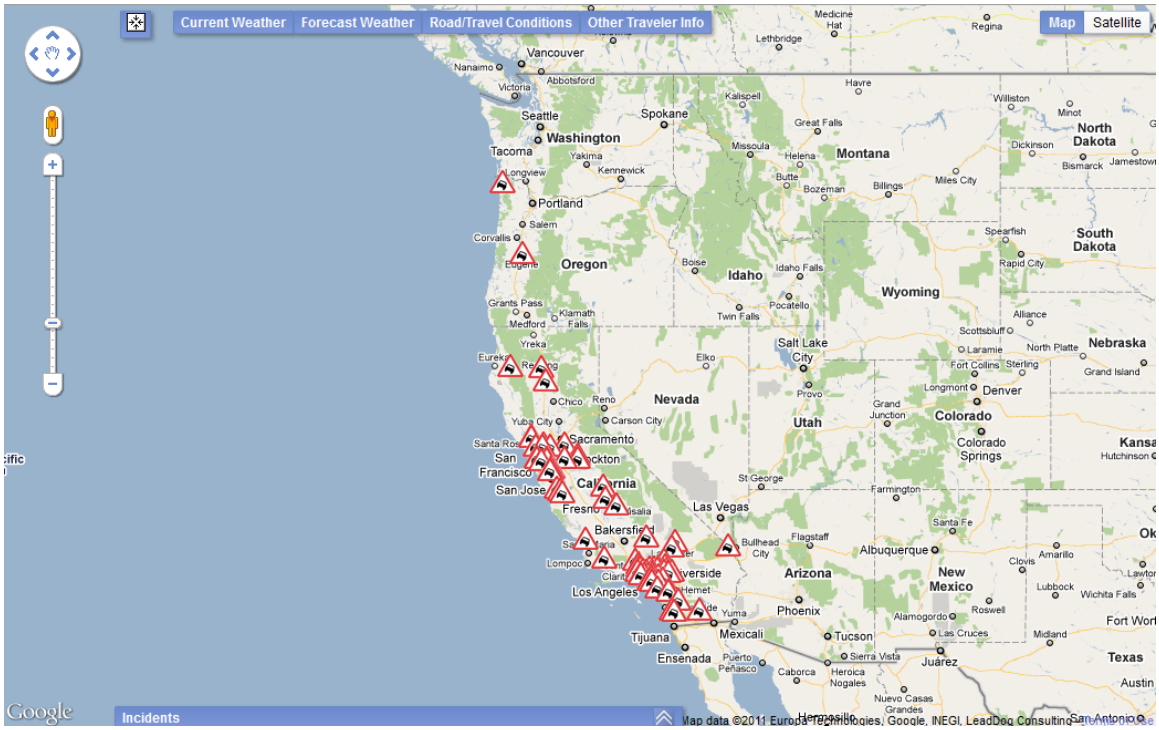

Figure 3-40. Incidents from the One Stop Shop Google Maps™ Interface (Data Source: CHP, ODOT)

Many different types of messages are shown in this layer, and usage and format may vary by state. See Figure 3-41 through Figure 3-45.

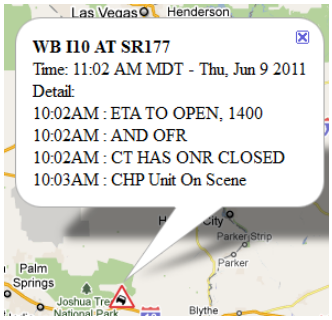

Figure 3-41. Closure Due to Incident as Report by CHP in Southern California from the One Stop Shop Google Maps™ Interface (Data Source: CHP)

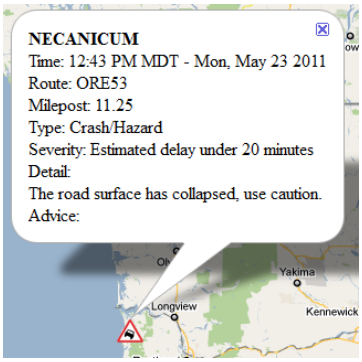

Figure 3-42. Road Surface Collapse in Oregon from the One Stop Shop Google Maps™ Interface (Data Source: ODOT)

Figure 3-43. Crash Information in Oregon from the One Stop Shop Google Maps™ Interface (Data Source: ODOT)

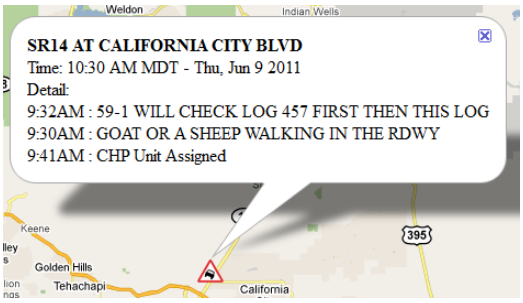

Figure 3-44. Animal Along the Road in California from the One Stop Shop Google Maps™ Interface (Data Source: CHP)

Figure 3-45. Overturned Truck on SR-99 in California from the One Stop Shop Google Maps™ Interface (Data Source: CHP)

CMS

Changeable message sign sites are represented with icons on the map. Signs with active messages are designated with a yellow-lettered icon. Signs with no message (inactive) are represented by the same icon with grey letters. Clicking on a sign icon displays the sign message. See Figure 3-46.

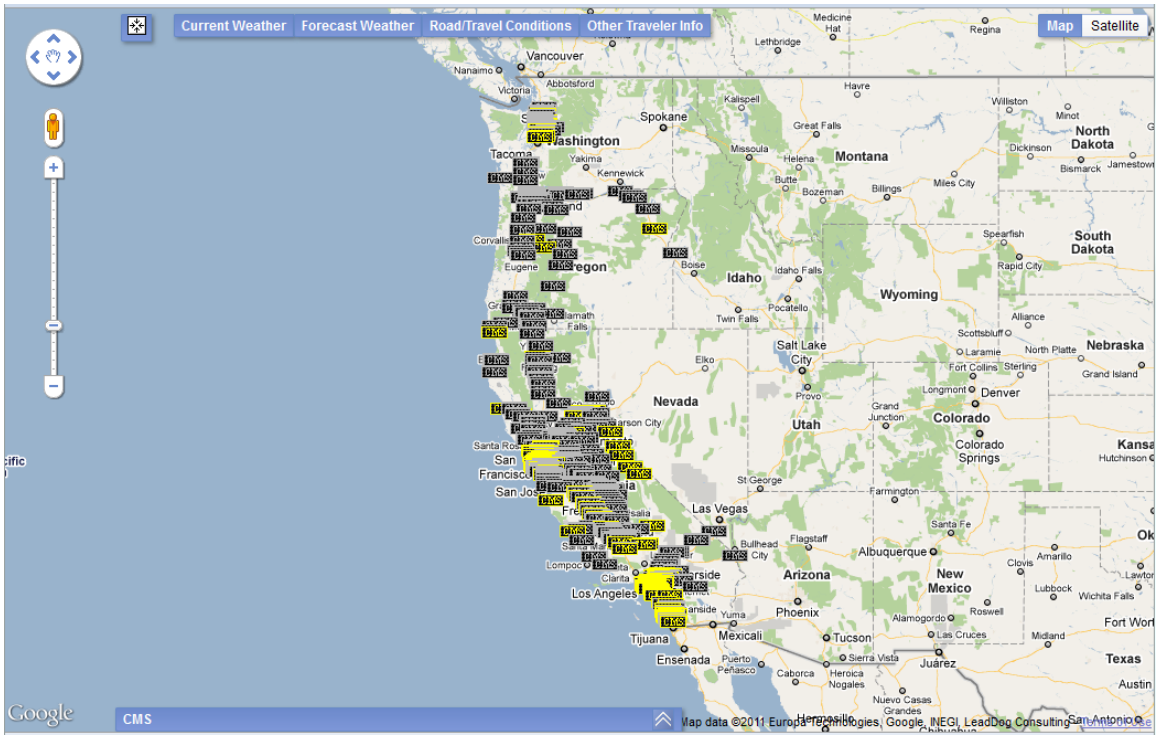

Figure 3-46. CMS Locations and Indication of Active Messages from the One Stop Shop Google Maps™ Interface (Data Source: Caltrans, ODOT, WSDOT)

Many different types of messages are shown in this layer, and usage and format may vary by state. See Figure 3-47 through Figure 3-55.

Figure 3-47. CMS Showing Snow Zone Message in Oregon from the One Stop Shop Google Maps™ Interface (Data Source: Caltrans, ODOT, WSDOT)

Figure 3-48. CMS Showing Road Work Message on Donner Pass in California from the One Stop Shop Google Maps™ Interface (Data Source: Caltrans, ODOT, WSDOT)

Figure 3-49. CMS Showing 2-Way Traffic Message on I-84 in Oregon from the One Stop Shop Google Maps™ Interface (Data Source: Caltrans, ODOT, WSDOT)

Figure 3-50. CMS Showing Road Construction Message on I-84 in Eastern Oregon from the One Stop Shop Google Maps™ Interface (Data Source: Caltrans, ODOT, WSDOT)

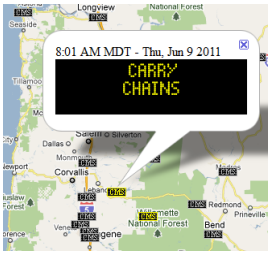

Figure 3-51. CMS Showing Chain Message in Oregon from the One Stop Shop Google Maps™ Interface (Data Source: Caltrans, ODOT, WSDOT)

Figure 3-52. CMS Showing Sharp Curve and Steep Grade Warning In Oregon from the One Stop Shop Google Maps™ Interface (Data Source: Caltrans, ODOT, WSDOT)

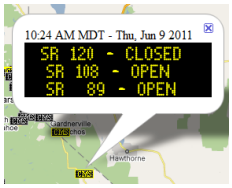

Figure 3-53. CMS Showing Road Status in Southeastern California from the One Stop Shop Google Maps™ Interface (Data Source: Caltrans, ODOT, WSDOT)

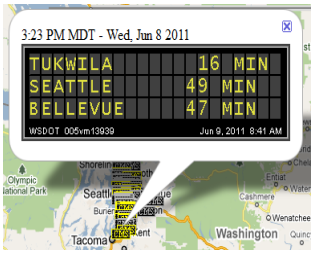

Figure 3-54. CMS Showing Travel Times Northbound on I-5 Near Seattle from the One Stop Shop Google Maps™ Interface (Data Source: Caltrans, ODOT, WSDOT)

Figure 3-55. CMS Showing Rest Area Closure on Donner Summit in California from the One Stop Shop Google Maps™ Interface (Data Source: Caltrans, ODOT, WSDOT)

CCTV

CCTV sites are represented with icons on the map. Clicking on a camera icon displays the camera image. See Figure 3-56.

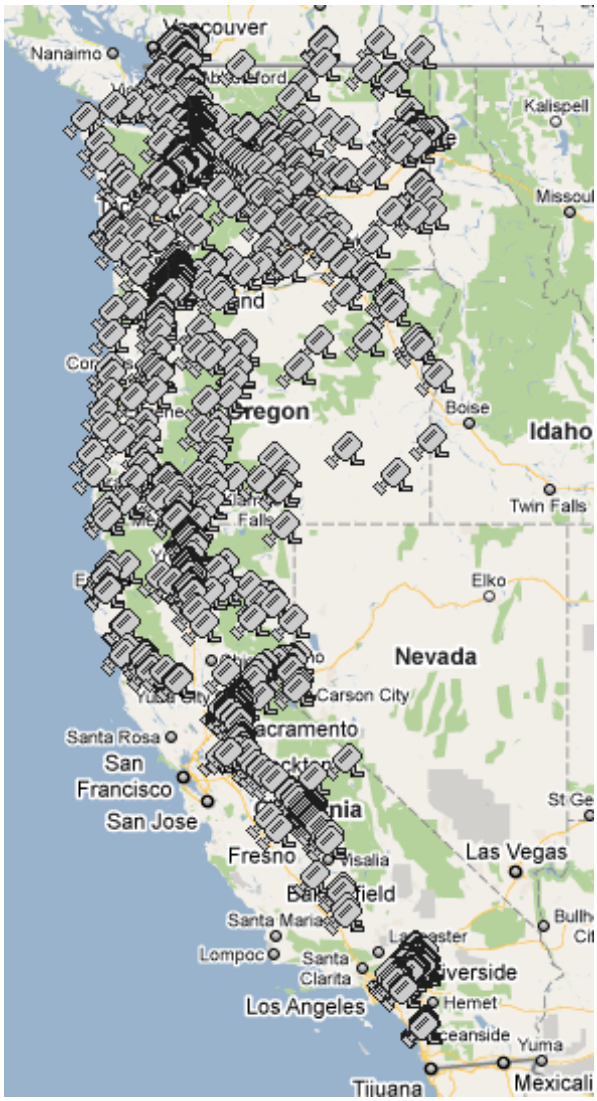

Figure 3-56. CCTV Layer from the One Stop Shop Google Maps™ Interface (Data Source: Caltrans, ODOT, WSDOT)

CCTV Images convey a lot of information. Image size and format may vary by state. See Figure 3-57 through Figure 3-64.

Figure 3-57. CCTV Image from Caltrans District 2 from the One Stop Shop Google Maps™ Interface (Image Source: Caltrans)

Figure 3-58. CCTV Image from ODOT Showing Siskiyou Summit from the One Stop Shop Google Maps™ Interface (Image Source: ODOT)

Figure 3-59. CCTV Image from ODOT Showing Snow and Poor Visibility on Siskiyou Pass from the One Stop Shop Google Maps™ Interface (Image Source: ODOT)

Figure 3-60. CCTV Image from Caltrans District 2 Showing Snow and Poor Road Conditions Approaching Siskiyou Pass from the One Stop Shop Google Maps™ Interface (Image Source: Caltrans)

Figure 3-61. CCTV Image from ODOT Showing Poor Visibility on US 20 from the One Stop Shop Google Maps™ Interface (Image Source: ODOT)

Figure 3-62. CCTV Image from WSDOT Showing Good Conditions on Snoqualmie Summit from the One Stop Shop Google Maps™ Interface (Image Source: WSDOT)

Figure 3-63. CCTV Image from ODOT Showing Rain and Wet Conditions on US 20 from the One Stop Shop Google Maps™ Interface (Image Source: ODOT)

Figure 3-64. CCTV Image from WSDOT Showing Good Conditions on I-90 from the One Stop Shop Google Maps™ Interface (Image Source: WSDOT)

Other Traveler Info

The other traveler information layer includes fixed locations and facilities such as rest areas, features of interest, truck scales and summit locations. See Figure 3-65.

Figure 3-65. Other Traveler Info Menu from the One Stop Shop Google Maps™ Interface

Rest Areas

Rest area locations are shown by icons on the map. See Figure 3-66.

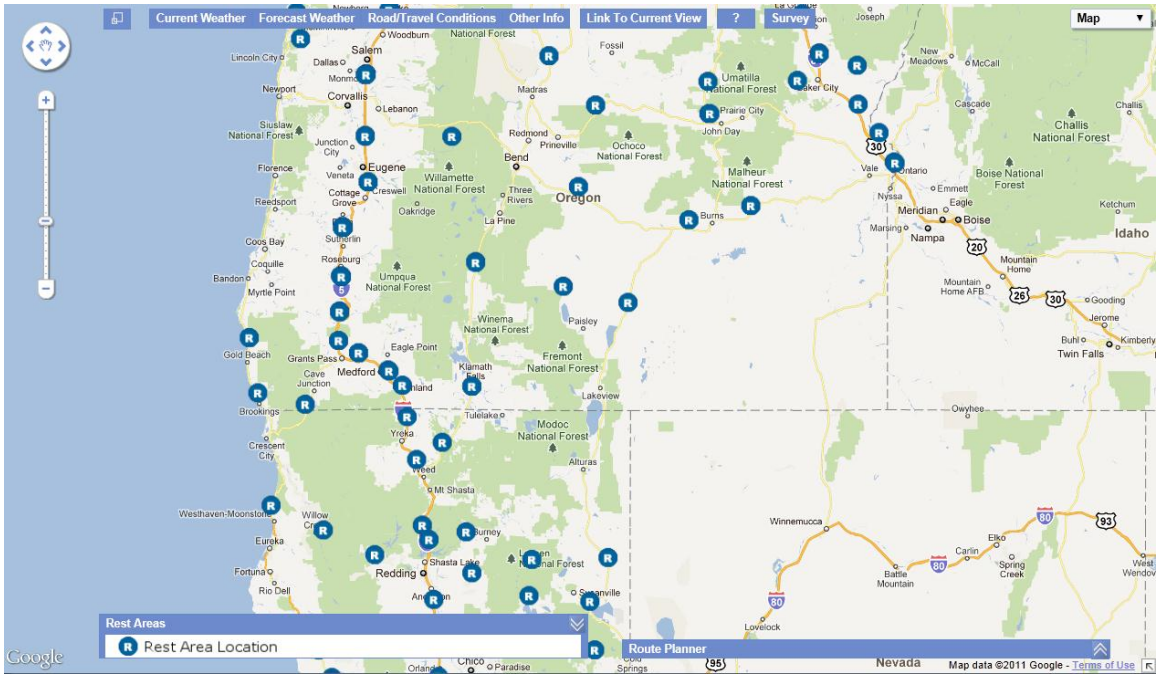

Figure 3-66. Rest Area Locations from the One Stop Shop Google Maps™ Interface (Data Source: Caltrans, ODOT, WSDOT)

Further information is shown by clicking on a rest area icon. Information shown varies by state and rest area. See Figure 3-67 through Figure 3-69.

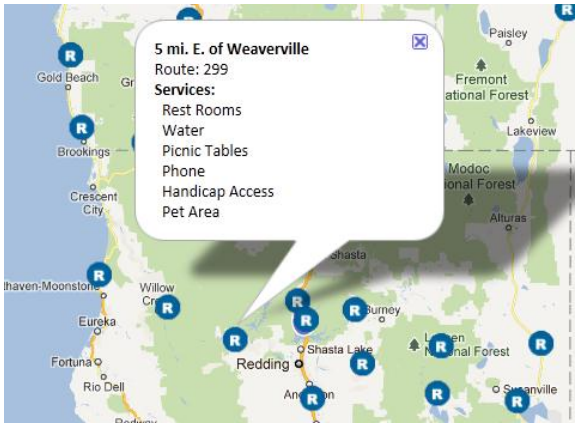

Figure 3-67. Rest Area Detail in California from the One Stop Shop Google Maps™ Interface (Data Source: Caltrans)

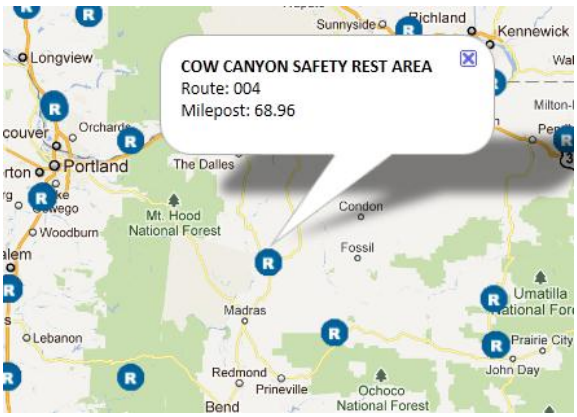

Figure 3-68. Rest Area Detail in Oregon from the One Stop Shop Google Maps™ Interface (Data Source: ODOT)

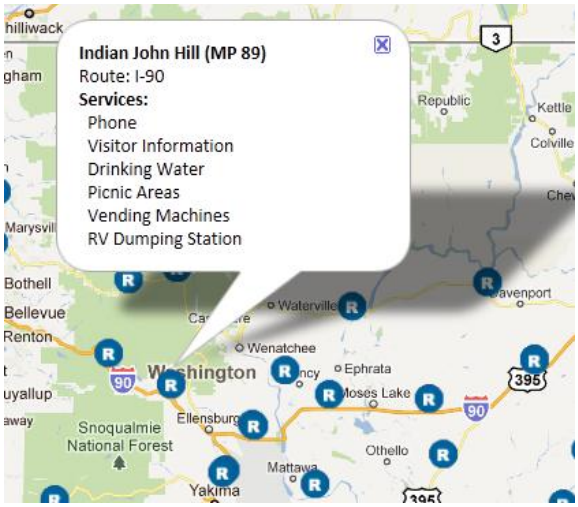

Figure 3-69. Rest Area Detail in Washington from the One Stop Shop Google Maps™ Interface (Data Source: WSDOT)

Features of Interest

Features of interest (generally vista points) are shown by icons on the map. See Figure 3-70.

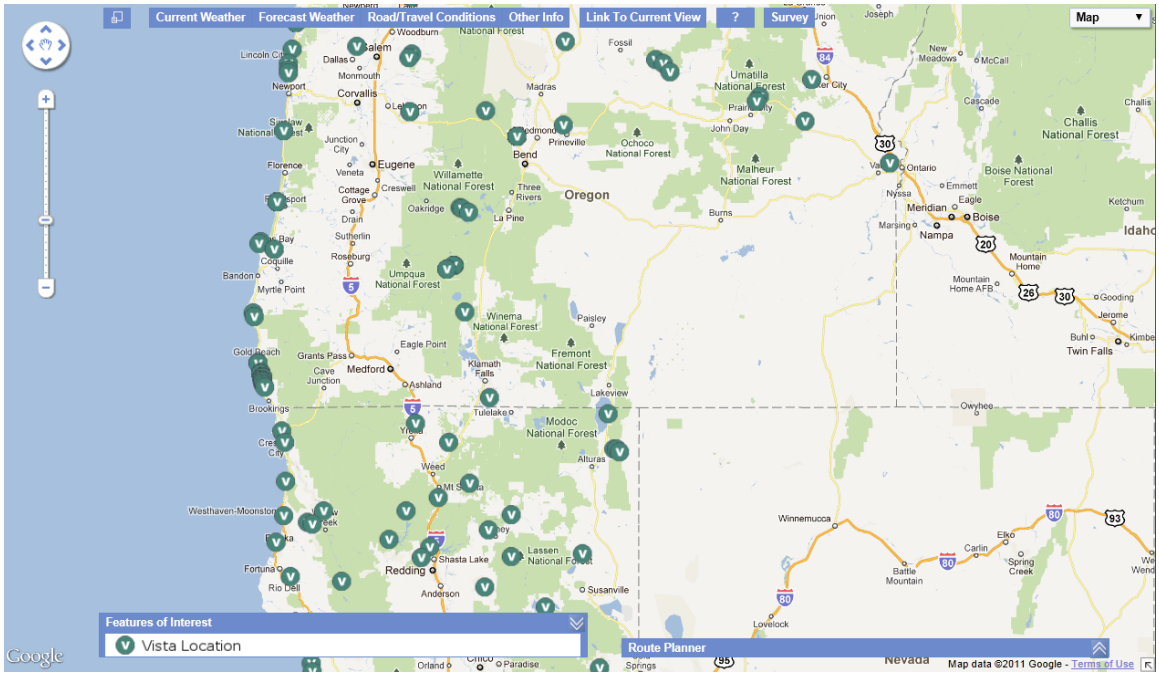

Figure 3-70. Features of Interest from the One Stop Shop Google Maps™ Interface (Data Source: Caltrans, ODOT, WSDOT)

Further information is shown by clicking on the icon. Information shown varies by state and site. See Figure 3-71 and Figure 3-72.

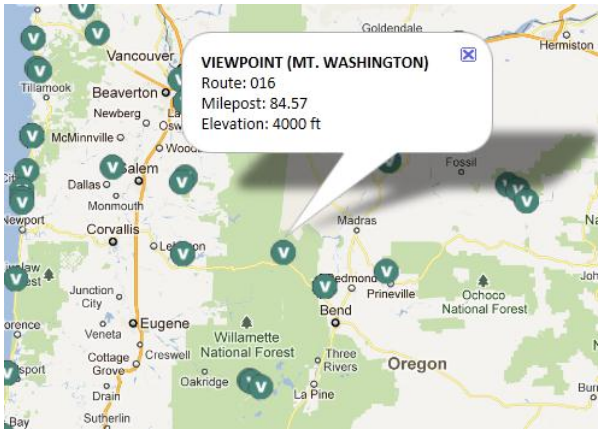

Figure 3-71. Vista Point Detail in Oregon from the One Stop Shop Google Maps™ Interface (Data Source: ODOT)

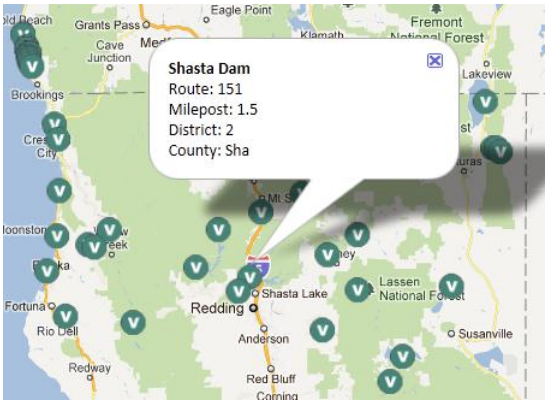

Figure 3-72. Vista Point Detail in California from the One Stop Shop Google Maps™ Interface (Data Source: Caltrans)

Truck Scales

Truck scales are shown by icons on the map. See Figure 3-73.

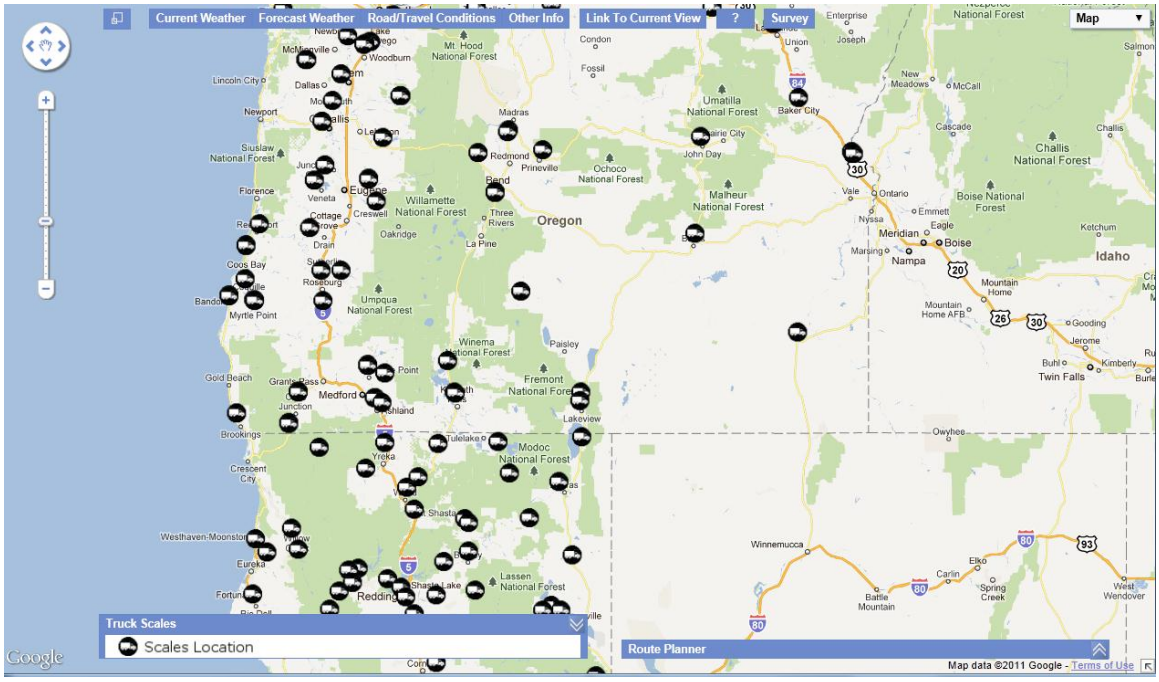

Figure 3-73. Truck Scales from the One Stop Shop Google Maps™ Interface (Data Source: Caltrans, ODOT)

Further information is shown by clicking on the icon. Information shown varies by state and site. See Figure 3-74 and Figure 3-75.

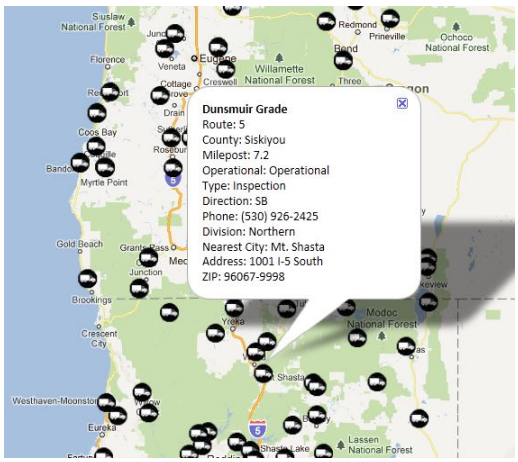

Figure 3-74. Truck Scale Detail in California from the One Stop Shop Google Maps™ Interface (Data Source: Caltrans)

Figure 3-75. Truck Scale Detail in Oregon from the One Stop Shop Google Maps™ Interface (Data Source: ODOT)

Summit Locations

Summit locations are shown by icons on the map. See Figure 3-76.

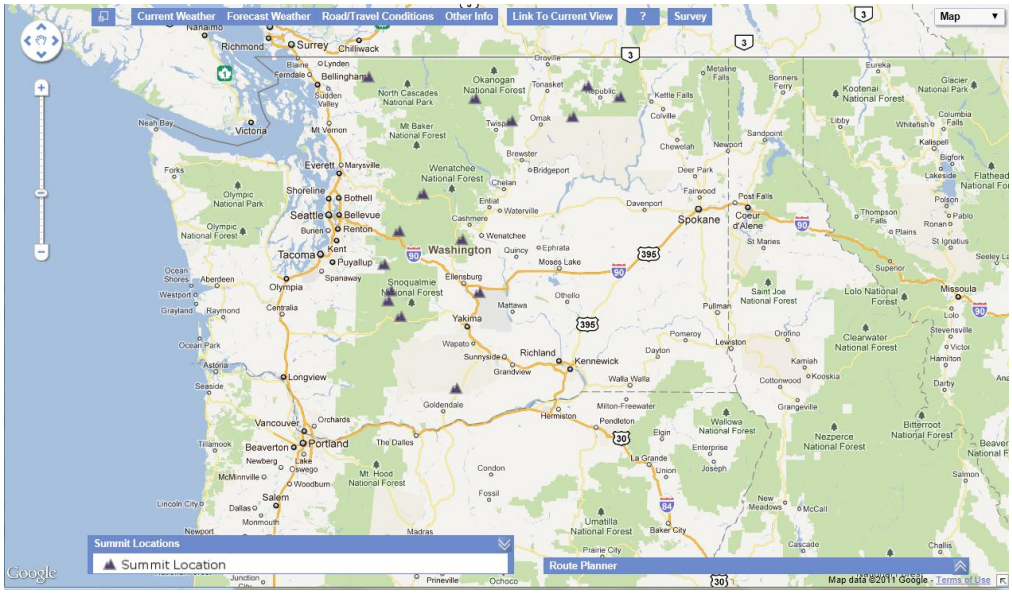

Figure 3-76. Summit Locations from the One Stop Shop Google Maps™ Interface (Data Source: Caltrans, WSDOT)

Further information is shown by clicking on the icon. Information shown varies by state and site. See Figure 3-77.

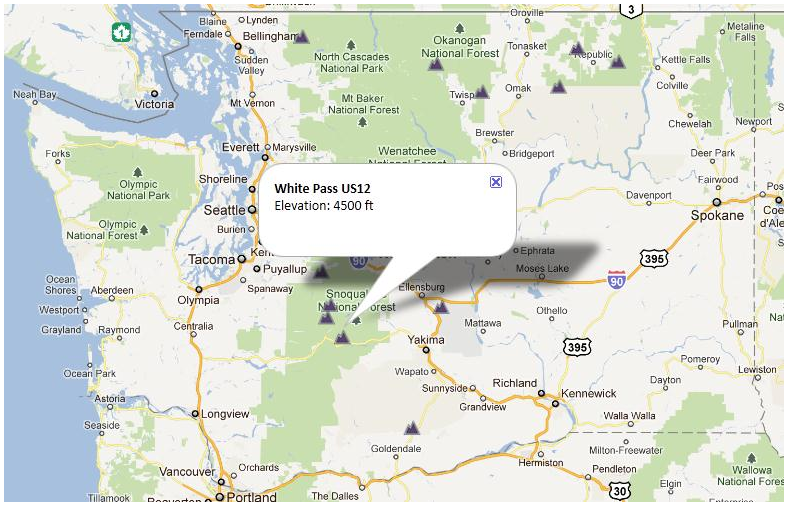

Figure 3-77. Summit Detail from the One Stop Shop Google Maps™ Interface (Data Source: WSDOT)

The Route Planner

The Route Planner allows users to generate a route between two points using Google's routing capability. The route is highlighted on the map with associated reference points. An elevation profile for the route is shown in the route planner with the same reference points positioned on the elevation profile. See Figure 3-78.

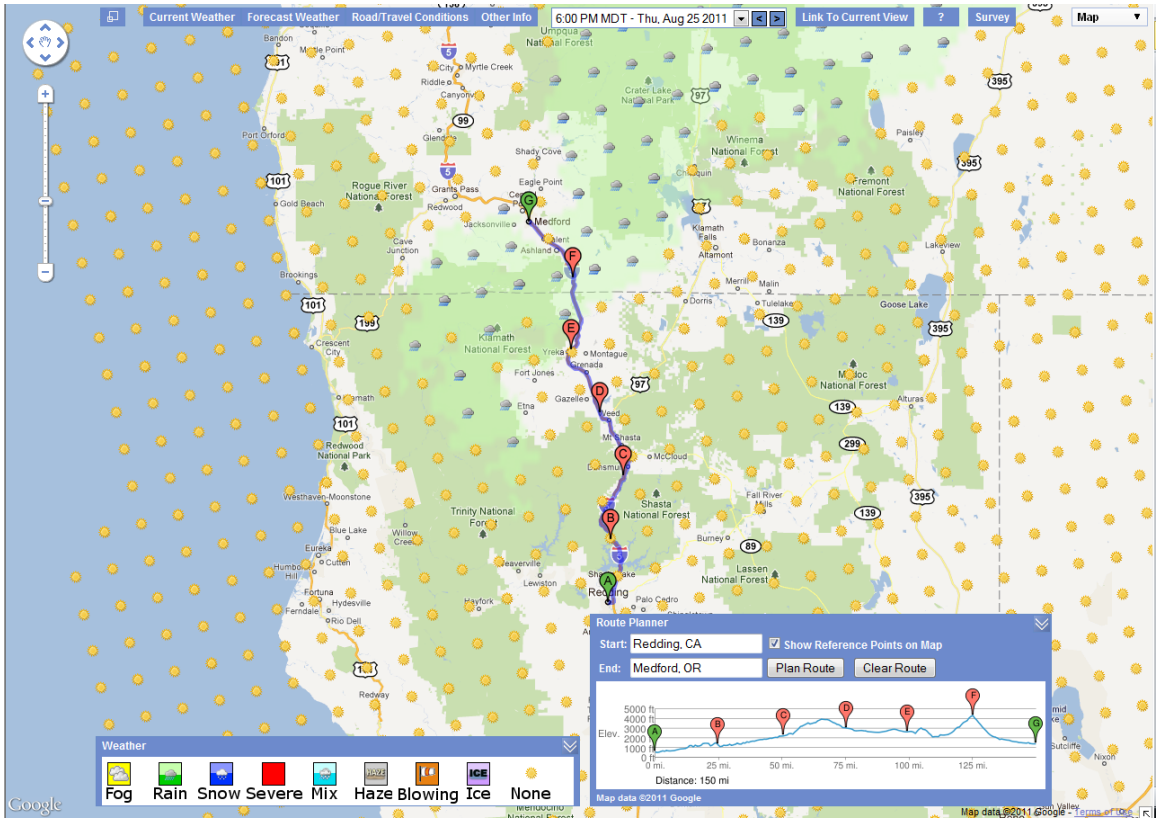

Figure 3-78. Route Planner from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD, Google Elevation Data Service)

Any layer can be viewed in conjunction with the route planner by selecting that layer. See Figure 3-79 through Figure 3-83. Travel times are not estimated via the route planner or within the system in general.

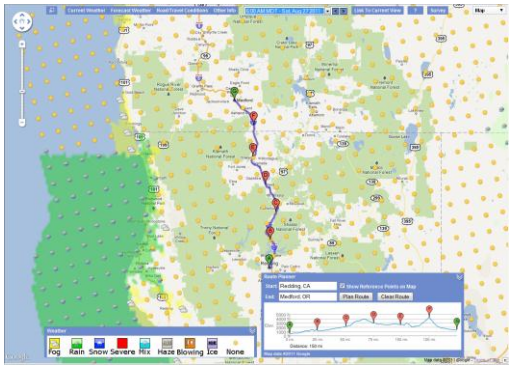

Figure 3-79. Route Planner with Weather Forecast Layer from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD, Google Elevation Data Service)

Figure 3-80. Route Planner with CMS Layer from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD, Caltrans)

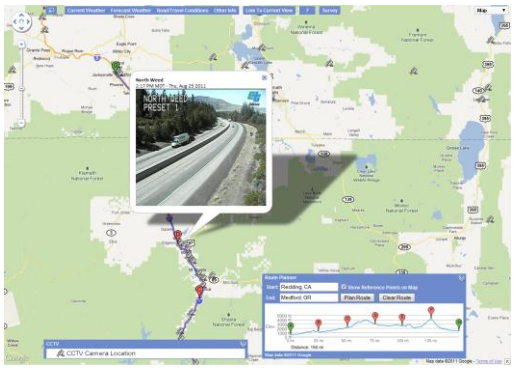

Figure 3-81. Route Planner with CCTV Layer from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD, Caltrans)

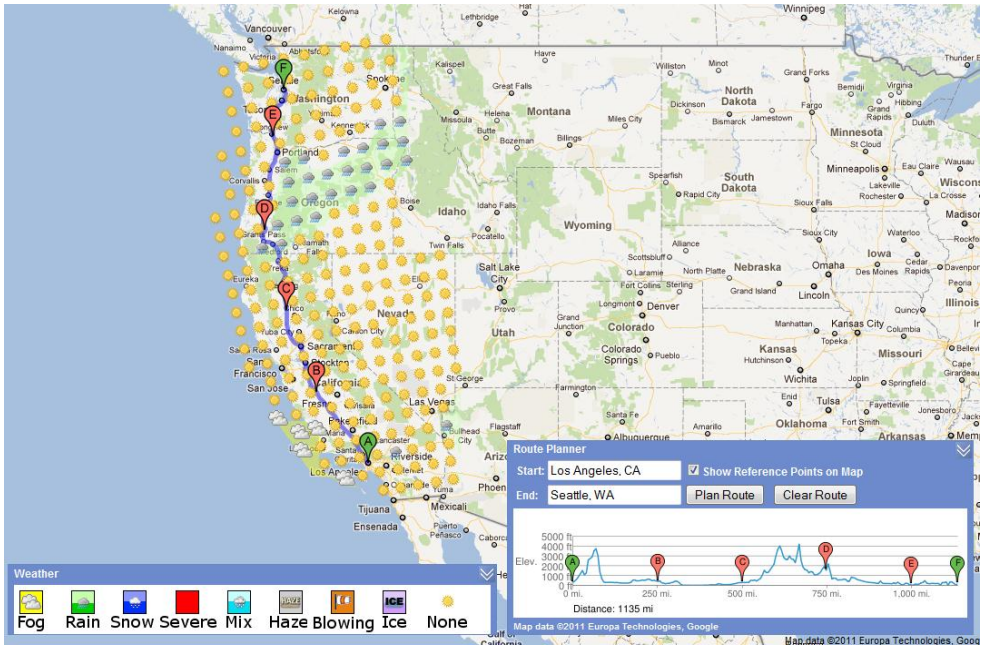

Figure 3-82. Route Planner Showing the Weather Forecast for Los Angeles to Seattle from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD, Google Elevation Data Service)

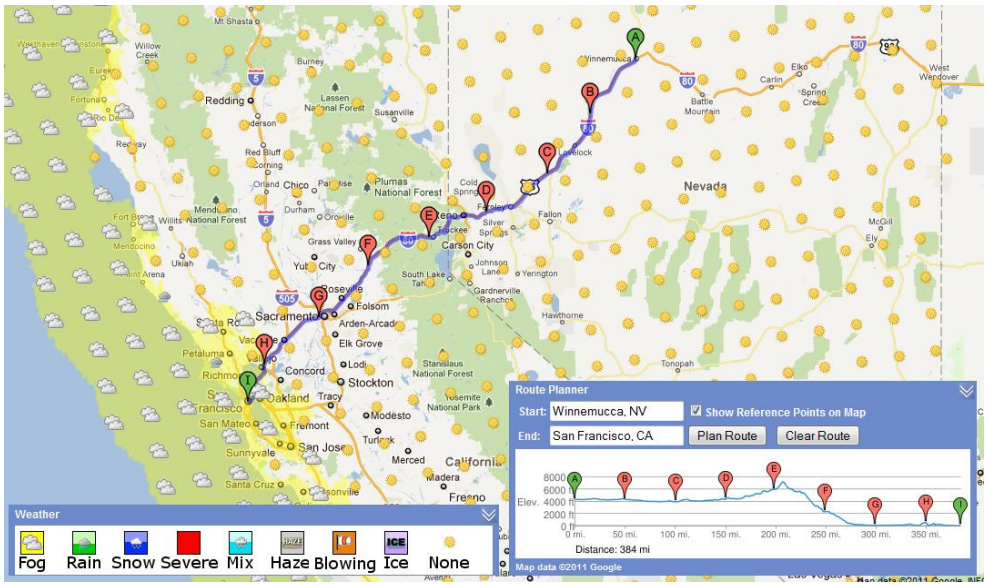

Figure 3-83. Route Planner Showing the Weather Forecast for Winnemucca to San Francisco from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD, Google Elevation Data Service)

Information at a Glance

The weather forecast layers exemplify the design goal of information at glance – conveying information in an intuitive fashion so that it can be readily interpreted upon view. The following figures, showing forecasts covering the four state regions, demonstrate this. See Figure 3-84 through Figure 3-86.

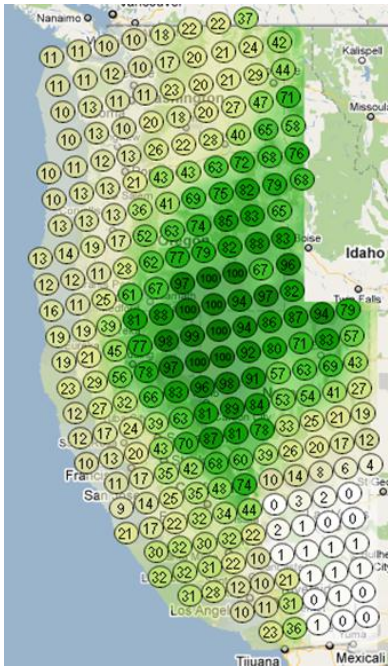

Figure 3-84. Probability of Precipitation Forecast from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD)

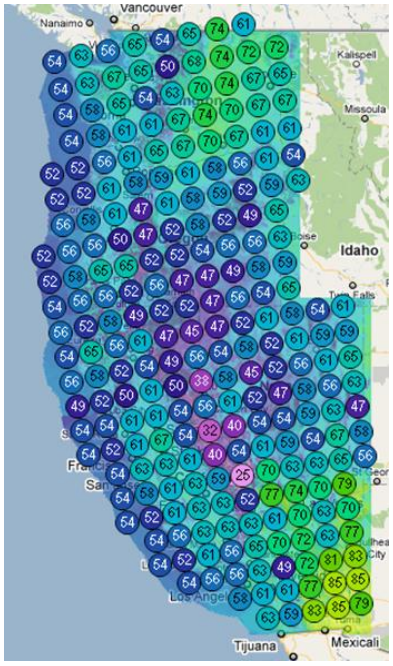

Figure 3-85. Temperature Forecast from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD)

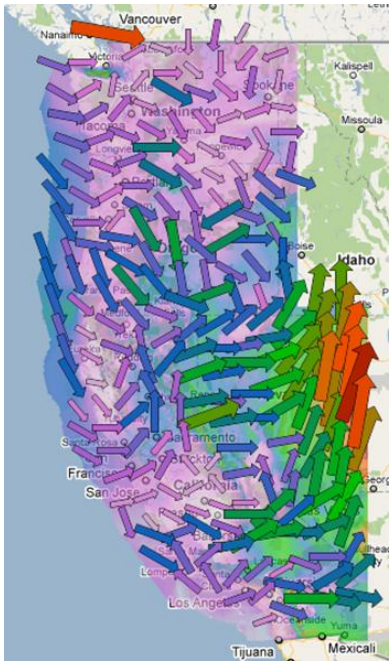

Figure 3-86. Wind Forecast from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD)

This design goal extends to usage of the system in transportation management centers (TMCs) and kiosks. The photo below shows the Western States OSS on a big screen in the Caltrans Division of Research and Innovation lobby in Sacramento. See Figure 3-87.

Figure 3-87. Western States OSS on the big screen in the Caltrans Division of Research and Innovation Lobby in Sacramento (Source: Sean Campbell, Caltrans)

Quality Control

Quality control checks are not performed on data displayed by the system beyond rudimentary (manual/visual) tests to determine that data is displayed in the correct location. Further, quality control data from data providers – mainly *Clarus*, MADIS and MesoWest – are not used to filter data nor are they displayed. This approach is deliberate and is consistent with the requirements for the system. It is recognized that quality control checks are important but are also less than perfect and can become quite complicated in terms of implementation. Current weather data, for instance, would require storage of values over time in the system to perform quality control checks, and it was determined that in this phase data would be discarded when it is no longer current. In subsequent development, quality control checks may be developed and used in the system in conjunction with quality control indications given by providers such as *Clarus*, MADIS and MesoWest.

The following example demonstrates the potential challenges of quality control checks for weather data.

In reviewing the site, one FHWA user examined the air temperature forecast display and inquired as to whether there was a problem with the forecast values in proximity the San Francisco. In checking the system on four consecutive days in the morning and then in the evening, the user found predicted temperatures that "seemed to be constant at about 56°F". To make sure that there wasn't an error in the system, the project team investigated the issue further.

For San Francisco and the Bay area in general, proximity to the coast has an impact on variability of air temperature. Minus a major change in the weather, the coastal areas have a fairly small daily range of temperature. This can change dramatically as you travel further inland, with temperatures on the coast of approximately 60 degrees and temperatures of over 100 degrees inland. Thus, the location of the corresponding grid point to which the forecast corresponds can play a significant role in determining the corresponding range and variability. For instance, here are forecast temperatures from July 7th, 2011 in proximity to San Francisco – see Figure 3-88 through Figure 3-92:

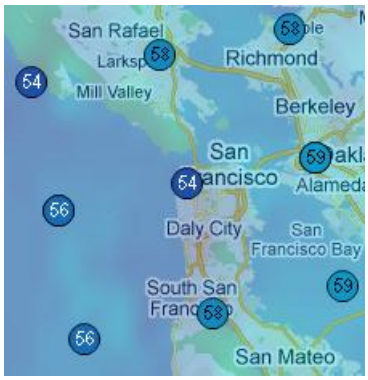

Figure 3-88. San Francisco Temperature Forecast for 7/7/2011, 8AM PDT from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD)

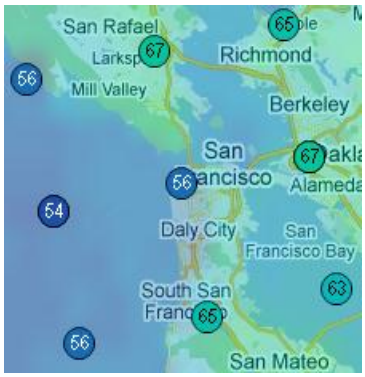

Figure 3-89. San Francisco Temperature Forecast for 7/7/2011, 11AM PDT from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD)

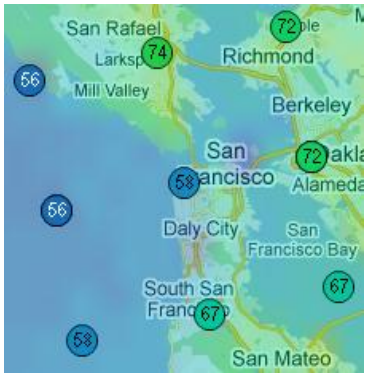

Figure 3-90. San Francisco Temperature Forecast for 7/7/2011, 2PM PDT from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD)

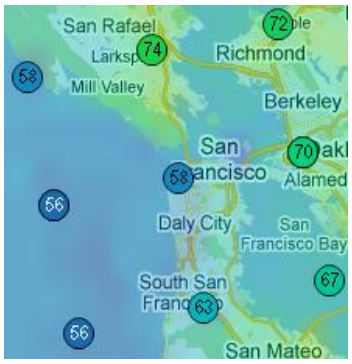

Figure 3-91. San Francisco Temperature Forecast for 7/7/2011, 5PM PDT from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD)

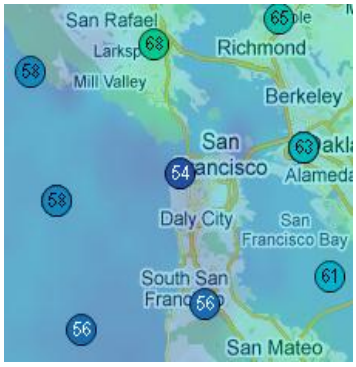

Figure 3-92. San Francisco Temperature Forecast for 7/7/2011, 8PM PDT from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD)

The forecast temperature values for the point on the west side of San Francisco (near Golden Gate Park) are shown in the following table – see Table 3-1:

Table 3-1. Forecast Temperatures in San Francisco for 7/7/2011 (Data Source: NWS NDFD)

Time	Temperature (degrees Fahrenheit)
7/7/2011 : 8AM PDT	54
7/7/2011 : 11AM PDT	56
7/7/2011 : 2PM PDT	58
7/7/2011 : 5PM PDT	58
7/7/2011 : 8PM PDT	54

Not only is range / variability small, but the temperatures at 8AM and 8PM are forecast as identical, which shouldn't be surprising when considering where they fall in what generally is a sinusoidal pattern. Here are forecast values for 8AM PDT and 8PM PDT for 7/8/2011 and 8AM PDT 7/9/2011 as well – see Figure 3-93 through Figure 3-95:

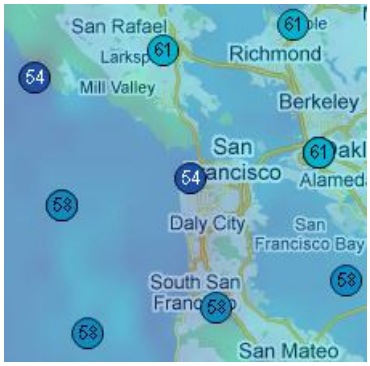

Figure 3-93. San Francisco Temperature Forecast for 7/8/2011, 8AM PDT from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD)

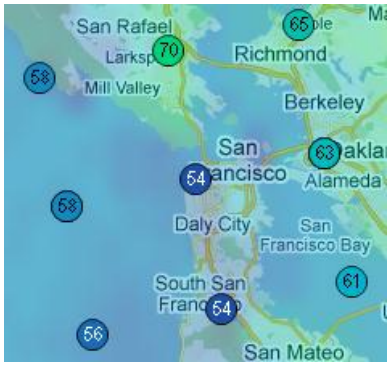

Figure 3-94. San Francisco Temperature Forecast for 7/8/2011, 8PM PDT from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD)

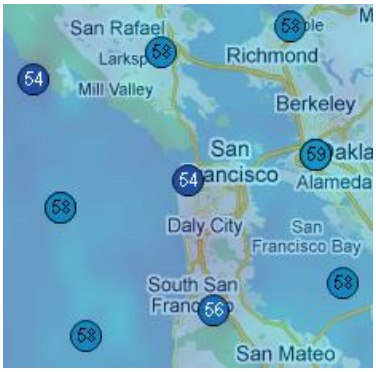

Figure 3-95. San Francisco Temperature Forecast for 7/9/2011, 8AM PDT from the One Stop Shop Google Maps™ Interface (Data Source: NWS NDFD)

The same 54 degree forecast is there for all of these. The question arises as to whether this is a problem with the NDFD data or a reasonable forecast.

The project team checked actual sensor readings in proximity to the forecast location, on 7/7/2011 at approximately 8AM Pacific Daylight time and consistent results were found. Most stations in San Francisco had readings of 54 degrees or very close to 54 degrees – see Figure 3-96:

Figure 3-96. San Francisco Sensor Temperatures at 7/7/2011, 8AM PDT from the One Stop Shop Google Maps™ Interface

The readings appeared to all be in line with expected / predicted.

For one of the stations (the station furthest west and in the middle showing a 51), the project team looked at historical data for the prior several days. The following plot shows hourly values since 7/4/2011 12AM PDT – see Figure 3-97:

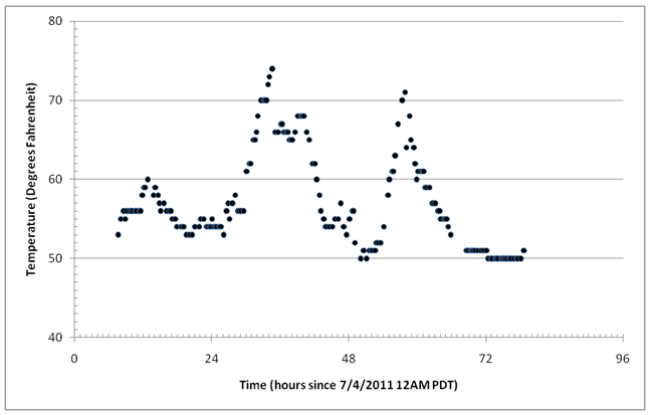

Figure 3-97. Hourly Temperatures at a site in San Francisco from 7/4/2011 through 7/7/2011. from WeatherShare

While there is notable variation in the data beyond a perfect sinusoidal pattern, it does appear to be in line with expected and predicted.

It was noted that forecasts in the system are no better than forecasts in general, despite coming from the National Weather Service. There certainly will be times and locations when the forecasts do not match reality. And, there will be places for which the underlying forecast models do not match reality due to microclimates caused by terrain, development, etc. However, there does not appear to be a problem with the forecast temperatures questioned above.

Chapter 4 User Survey and Evaluation

Given that the website that has been developed represents a different approach to the presentation of weather and traveler information for many users (especially the traveling public), a user survey was conducted to solicit feedback that will be useful for perfecting the system. Such a survey was acknowledged to be a challenge, as the website would be unadvertised; as a result, potential visitors and survey respondents would only learn of the site and visit it through word of mouth. The result was the potential for only a limited number of survey responses to be collected. Consequently, supplemental information collected through Google Analytics™ was also examined in order to further understand how visitors used the website. Further, the survey was conducted during late summer when, arguably, weather conditions are most favorable for travel and when the website is least likely to reveal weather-related travel challenges, and construction and maintenance work would contribute most to prospective delays and changes in travel plans. Combined, the results of the user survey and information from Google Analytics™ provide feedback which will be employed in future revisions and improvements of the website, while recognizing that the results only cover a portion of anticipated conditions and related use. The following sections discuss the user survey and information collected through Google Analytics™.

User Survey

The user survey was conducted in an electronic format (SurveyMonkey) and presented to users via a link on the One-Stop Shop website. The survey asked users for feedback and comments regarding various aspects of the website, including appearance, usefulness, etc. The survey instrument is presented at the end of this document in Appendix A. The survey was brief (requiring 5 to 10 minutes to complete) and was developed in consultation with the project panel. A link for both the project website and the user survey were sent to interested parties (the FHWA project manager, Western States Rural Transportation Consortium members, etc.) on Wednesday, August 3, 2011, with the user survey responses collected through Monday, August 22, 2011 compiled for this report. Parties supplied with the website addresses were asked to forward them along to anyone they knew who might be interested in traveler information, including colleagues, family and friends. In total, 13 survey responses were collected; this was expected, given the limited audience that was alerted to the existence of the website and survey. While it was hoped that word of mouth would have increased the exposure of the website and resulting survey sample size, the limited period of time that responses were collected (in light of remaining project timeline) did not allow for such an event to fully occur. Regardless, it is believed that the feedback obtained here provides useful information which can be employed when future modifications and improvements are made to the One-Stop Shop website. The following subsections summarize the responses obtained through the user survey.

Survey Respondents

A total of 13 users completed the survey as of August 22, 2011. Responses were obtained from users in California, Nevada, Oregon, Washington State and Washington, D.C. Of course, this is only a fraction of the total visitors to the website, and as the information presented in the Google Analytics™ portion of this chapter will indicate, website visits from a number of other states occurred as well. Of the thirteen users who completed the survey, seven identified themselves as being members of the general public, while six were transportation professionals (ex. DOT staff). Unfortunately, no responses were obtained from the other user groups of interest, including goods movement/commercial trucking and law enforcement. Despite the lack of feedback from these groups, the information provided by those who did complete the survey has provided useful insight into the views of the One-Stop Shop website by key segments of its intended audience.

Website Visits

The initial survey question asked users how often they visited the website. The response results are presented in Table 4-1. As one would expect for a newly developed website, over three quarters of users (10) indicated that they were visiting the site for the first time. The remaining 23 percent of visitors indicated that they visited the website on a weekly basis. Consequently, the remainder of the survey results presented in this chapter may be considered feedback from users who were completely unfamiliar with the website and its approach to presenting weather and traveler information.

Table 4-1. User visit results

How often do you visit the website?	Response Percent	Response Count
First time visitor	76.9%	10
Website is open all the time	0.0%	0
Hourly	0.0%	0
Daily	0.0%	0
Weekly	23.1%	3
Monthly	0.0%	0
Other (please specify)		0

Use of Information

The next survey question asked users how they used or intended to use the information presented by the website. The response results to this question are presented in Table 4-2. Respondents could select more than one use, which the results indicate many did. The greatest use of the site was for travel planning (nearly all respondents), with use during incidents (weather, fire, etc.) being another highly selected category. Only a limited number of responses (2-3) indicated the use of the website only during changing conditions, during the day or during the night. The single “Other” response came from a user who indicated they were a weather hobbiest and would use the website in that capacity.

Table 4-2. Information use

When/why will/do you use (or intend to use) the information?	Response Percent	Response Count
Trip planning	92.3%	12
Under changing conditions only	23.1%	3
During incident conditions (storm/fire etc)	61.5%	8
Daytime hours	15.4%	2
Nighttime hours	15.4%	2
Other (please specify)		1

Current Weather Data

Survey respondents were next asked about the usefulness of the current weather data provided by the website. The results of this question are presented in Figure 4-1. As the figure indicates, the most useful information as indicated by users was air temperature, 1-hour precipitation and 24-hour precipitation. Relative humidity and wind speed/direction information was found somewhat useful. Only small numbers of users indicated that they found a particular data element not very useful or were unaware of it, which is encouraging. This indicates that most users thoroughly reviewed all data elements and perceived some utility from them.

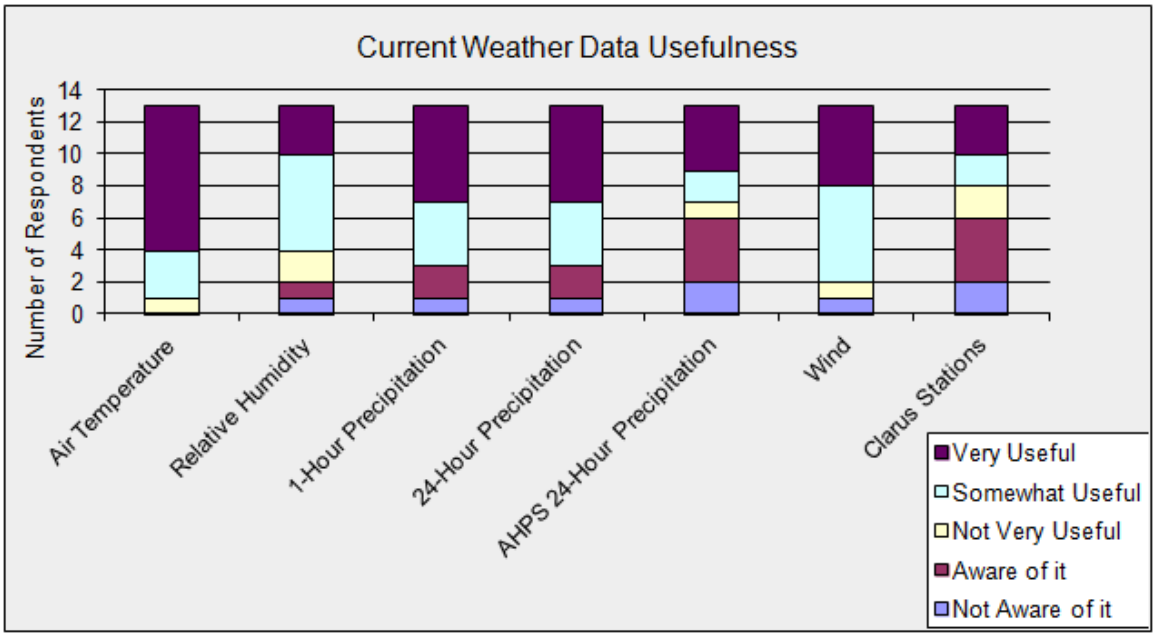

Figure 4-1. Usefulness of current weather information (note: AHPS - Advanced Hydrologic Prediction Service)

Forecast Weather Data

As a follow-up to the use of current weather data, users were asked their views of the usefulness of various forecast weather data elements. The results of this question are presented in Figure 4-2. As one would expect, users found the forecast information for air temperature, snow and weather very useful. Users also indicated that 6-hour and 12-hour precipitation and wind gust speed information was also very or somewhat useful. Overall, most of the forecast weather information provided was rated as having some level of utility to users, although humidity and sky cover information did receive some responses indicating they were not very useful.

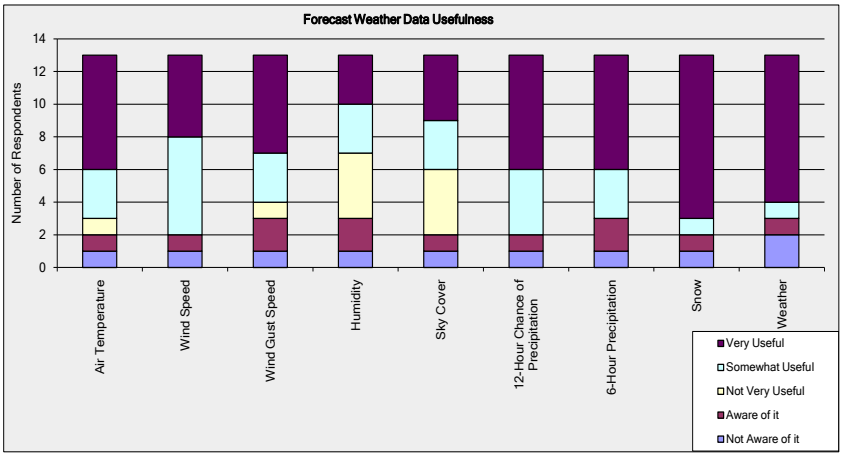

Figure 4-2. Usefulness of forecast weather information

Road/Travel Condition Data

Given that one of the functions of the One-Stop Shop website was the provision of traveler information, it was of interest to obtain feedback on the utility of these data streams. The first set of travel information users were surveyed on were road/travel conditions. The results of the usefulness to users of different road/travel condition data is presented in Figure 4-3. As this figure indicates, users found all of the road/travel condition data presented on the website very or somewhat useful. This was not surprising, as the information in this dataset is typically of great interest to travelers in determining conditions along their expected routes, particularly closed circuit television (CCTV) images (to view existing weather/conditions), road information (ex. construction, etc.) and incidents (ex. accidents). Changeable message sign text was also found to be very or somewhat useful to users, which is encouraging, as this information is not necessarily provided by some traveler information websites. One item that should be viewed with caution at present is the usefulness of chain control information (when drivers are required to carry/use traction chains on their vehicles) indicated by respondents. While this information would be of use to a website visitor during the winter when chain controls are active and displayed, no such information was presented at the time of the survey (August, 2011) when users could view it.

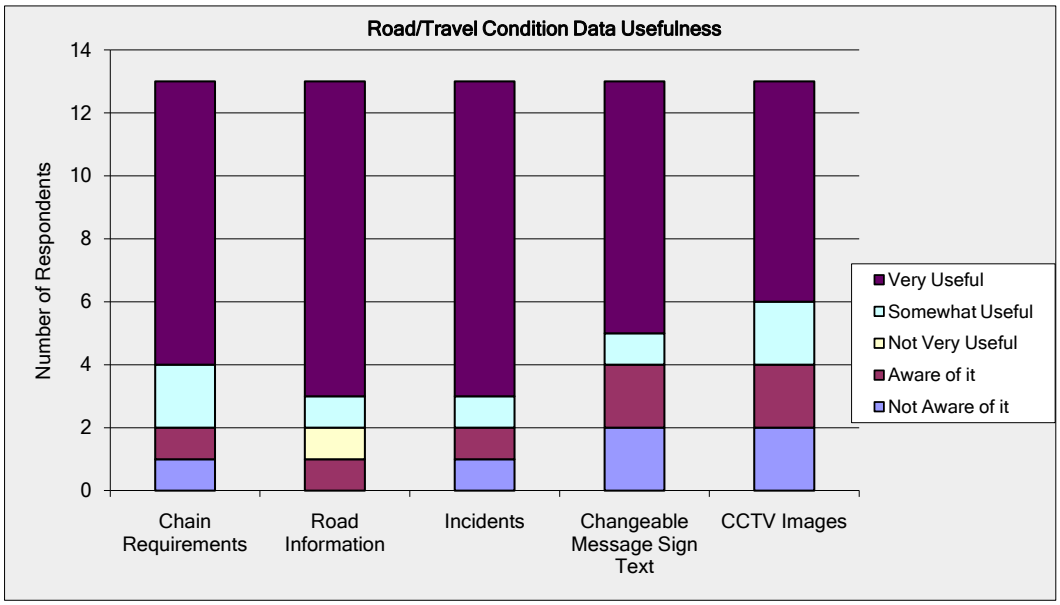

Figure 4-3. Usefulness of road/travel condition information

Other Travel Data

In addition to more real-time data streams such as CCTV images, the One-Stop Shop website also provides users with more static information, such as the location of rest areas. In line with this, users were asked for their views regarding the utility of this information. The results for the question on this question are presented in Figure 4-4. Overall, users once again found all of the data streams to be very or somewhat useful. However, most of the responses received regarding features of interest, truck scales (weigh stations) and summit locations were rated as being somewhat useful. Of course, in the case of the later two elements, this information may be of greater interest to the goods movement industry, which none of the respondents were from.

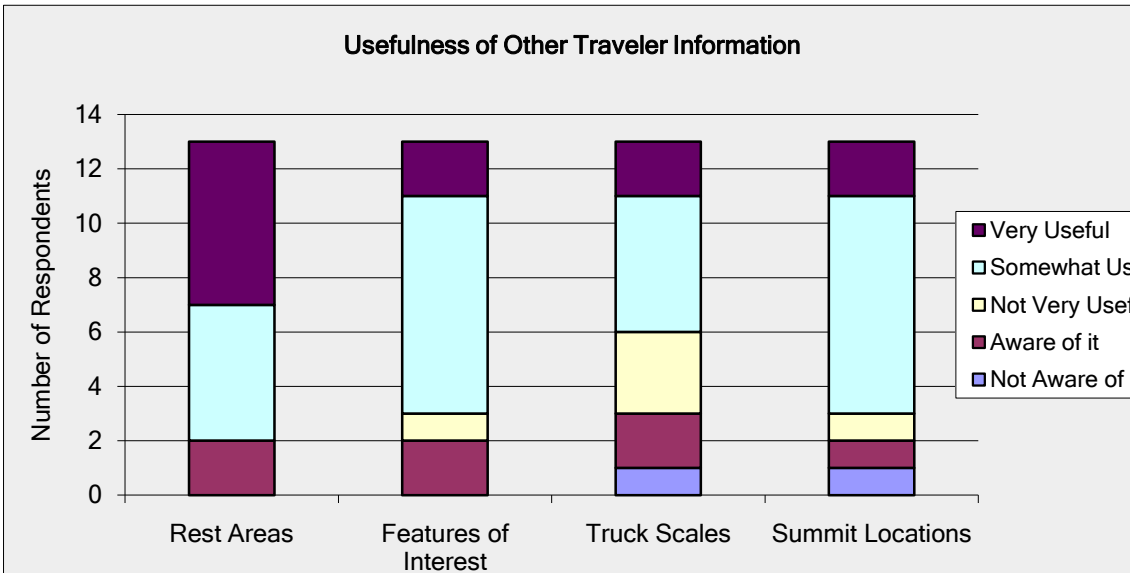

Figure 4-4. Usefulness of other traveler information

Website Features

Next, users were asked for their thoughts on general website features and functions. The results from this question are presented in Figure 4-5. A clear majority of users found the Google Maps™ display and zoom function very useful, which is not surprising given the familiarity and acceptance that the general public has developed for this particular mapping format. This finding was useful in that it somewhat validates the use of the Google Maps™ format for the presentation of data on the website. Similarly, a number of users found the Google satellite imagery to be a very useful feature. Google's terrain was also indicated as being very or somewhat useful to most users. Finally, most users found the route planner feature to be very or somewhat useful. Again, this is encouraging, as one of the intentions of the website is to serve as a trip planning tool.

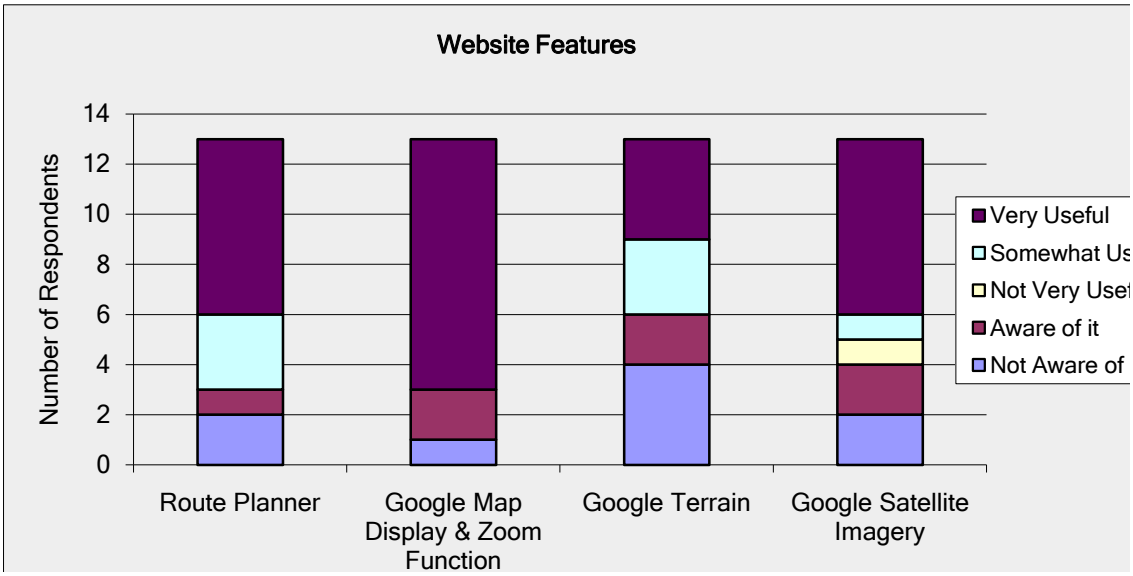

Figure 4-5. Usefulness of website features

Website Perceptions

Next, users were asked about their perceptions of various aspects of the website. All users agreed to some extent that the website was well organized and user friendly. Similarly, most users expressed that the website provided the right amount of information. When asked whether additional information should be presented, four respondents disagreed, while the remaining nine had a varying opinion ranging from agreement to no preference. As one would expect, these views remained somewhat constant when asked whether less information should be presented. Regarding this question, three respondents indicated that less information was preferred, while the remaining two respondents' opinion ranged from no preference to disagreement with the statement. Collectively, the responses to these two questions provide an initial indication that most website visitors were comfortable with the type and quantity of data being presented.

Next, users were asked whether the information should be presented in a different format. Only three respondents indicated that they agreed to some degree that a different format should be employed, three expressed no preference, and seven indicated disagreement with the statement. Consequently, it appears that a slight majority of users were comfortable with the existing presentation format. When asked if the information being presented was timely and useful, twelve users indicated that they agreed with this statement, while one user expressed no preference. Similarly, all users agreed to some degree that the information presented was accurate and understandable.

Table 4-3. Website perceptions

Perceptions of website	Strongly Agree	Somewhat Agree	Neither Agree nor Disagree	Somewhat Disagree	Strongly Disagree	Count
The site is well organized and user friendly.	6	7	0	0	0	13
The site presents the right amount of information.	5	6	1	1	0	13
I would like to see additional information added.	2	2	5	4	0	13
I would like to see less information presented.	0	3	2	6	2	13
Information should be presented in a different format than the current one.	1	2	3	6	1	13
I find the information presented timely and useful.	9	3	1	0	0	13
I find the information presented accurate and understandable.	7	6	0	0	0	13

Additional Information Feedback

Following the general survey questions, users were provided an opportunity to provide their own feedback on different subjects. The first question posed pertained to additional information that could be provided by the website. It asked: What additional information, if any, would you like to have, which is not available currently at this site? (Please specify the type, format, frequency of updating, and accuracy of data, if applicable.). Seven users provided responses to this question:

- Highway Advisory Radio activation and messages.
- Nothing additional, very good content.
- There are no Features of Interest for Washington State. Please add.
- It was confusing where some of the functions required that you click on the icons to obtain information whereas other "icons" were actually the information. There's a bit of a Human Factors element going on here. I realized it after playing with the site, but I wonder if a wider audience might become more easily frustrated.
- You may want to consider for the static icons indicating the unit of measurement on the drop down menu (i.e. Celsius vs. F).
- More States included, this is an incredible tool and I would use it even more if I could use this for more states. Great job team! Very practical and intuitive! I'm sharing this with everyone that I know who travels in those regions!
- Continuous profile of weather forecast. Especially precipitation and alerts for potential ice/chain control on roadways.
- Under the "Road/Travel Conditions" tab I would like to see flow data available as an option. WSDOT data is available through our API at: http://webpub3qa.wsdot.wa.gov/traffic/api/

As these responses indicate, some simple improvements to the site have been suggested (ex. indicating Celsius versus Fahrenheit) as well as more complex data presentations (incorporation of traffic flow data). The feedback provided by users for this question will be considered when future updates and improvements are made to the website.

Chief Website Benefits

Users were next asked what they thought the chief benefits of the website were. Nine users provided responses to this question:

- Weather on route I'm taking, information on potential travel delays.
- Pre-trip planning and the ability to actually view conditions (CCTV, Chain Control, CMS, etc.) along a route seamlessly.
- Provides information concerning road conditions and weather forecasts on one website.
- Being able to actually see the road and weather conditions via the CCTV images is great. Seeing the things that could affect travel, such as incidents and construction, right on the map is definitely useful. The terrain is also interesting and gives a good perspective. The wind display is just cool.
- Information for road travel.
- Weather hobbyist and amateur radio operator. This site will be interesting from a hobby point of view and will be helpful during bad weather.
- Current and future weather conditions along planned route. Current incidents and future/ongoing roadwork along planned route.

- There are so many, I love that you can see the CMS signs, that gives great data to a traveler, and to be able to see them in advance, awesome, The weather forecast data was very useful as was the current weather data. I love all of the different features on here.
- Trip planning.

As these responses indicate, different users saw different benefits from the website, depending on their own circumstances. However, in reviewing these responses, one can make the overall conclusion that the real-time and near-real time data being provided (weather, CCTV images, incidents, etc.) is viewed by users as a significant benefit in planning for a trip.

Website Improvements

The final survey question posed to users regarded improvements they would like to see made to the website. Ten users provided responses to this question:

- The route planning box covers up part of the route on my screen. If planning box could be moved rather than the map being moved on the screen reading would be easier.
- There is a lot of potential with this project. The work done to date is very good. Speed and performance are much improved. Weather info is useful and the forecast info is good. Need to do quite a bit of work on the look and feel. Menu at top is disjointed and is distracting - make one blue bar across the top with the pull downs. Need to launch with elements and other road related conditions first. Weather is important but should be secondary to the elements (meaning it is all there as it is now but you go to it generally after you have looked at the elements and what is happening on your route). Should come up with elements first (CCTV, CMS, RWIS, HAR, Construction, Chain Control and Incidents) and at a zoom level that is workable. Don't try to show the entire region on the big map upon launching the site. Use a small map (shows just the entire WSRTC region) on the right that has a movable box showing the area covered by the big map. When a new user gets into the site, determine where they are from by their ISP and orient the big map location using that info. They can then move where they want from there (using the small right hand map or on the big map) and adjust the zoom level on their own. When the route planner is launched, show the route on the small map (in addition to part of the route covered on the big map) and orient the big map at the starting point of the route. Try to show the markers associated with mountain passes along the route. I have a few other things we can discuss later.
- More information in Nevada. Alerts. Quality control or flags? Current weather sky cover.
- It was hard to understand some of the coding for the areas cited, for instance when looking at the temperature for a certain area.
- Road Information has too many flags. Noticed that one closure had hundreds of flags going along the length of the closure. It is too much and overkill. Is there a way to separate out the daytime and nighttime closure? There's generally a lot more nighttime closures which overpowers the daytime closure flags. Most commuters/non-commercial drivers are only interested in daytime closures.
- I have accessed this site from different PCs/networks and load and refresh rates seem a bit sluggish. This will not inhibit me from using the site.
- Present "Route Planner" more prominently and, as an option, limit Road/Travel Condition icons to the planned route only. The temp and other weather circle icons on the map make it very busy. Try making the weather and temperature "circles" an optional display or another alternative is to simply remove the circles and use text only on a color map.

- Again, I thought it was very intuitive, I would just like to see it include more states to add to its usefulness
- User guide videos (short 1-3 mins) will be useful as well because I don't think we are used to having this much useful information in one place!
- Currently you can only see one "Road/Travel Condition" element at a time. It would be nice if these features were layers on the base map that could be overlayed, enabling us to see several different features concurrently.

As these responses indicate, there are a number of improvements that users would like to see made to the website. Given that the development of the website is still in its initial stages, this type of feedback provides a good foundation on which future updates and improvements can be planned and pursued.

Google Analytics™

In addition to the information collected by the website survey, additional user information was collected through the use of Google Analytics™. This is a tool which tracks website usage patterns, including individual site visits, time spent on the site and the features selected. The following sections summarize the key information collected through this approach for the One-Stop Shop website.

Site Visits

An email alerting interested parties to the One-Stop Shop website was sent on August 3, 2011. As one would expect, there was an initial surge in visits to the website immediately following its announcement, with 55 visits on August 3rd. Table 4-4 presents the total visits, by date, to the website. A total of 244 visits were made to the website. There were 128 unique visitors, although this number does count visits by the same person at different locations/computers as multiple unique visitors. One interesting observation is the tendency for traffic to pick up following weekends; whether this is repeat visitors coming back to the site to review information from their state on a weekly basis or new visitors is not clear. It may also be attributable to invited reviewers viewing the site at work.

Table 4-4. Website visits, by date from Google Analytics™

Day	Visits
Wednesday, August 3, 2011	55
Thursday, August 4, 2011	28
Friday, August 5, 2011	32
Saturday, August 6, 2011	0
Sunday, August 7, 2011	2
Monday, August 8, 2011	43
Tuesday, August 9, 2011	13
Wednesday, August 10, 2011	7
Thursday, August 11, 2011	8
Friday, August 12, 2011	4
Saturday, August 13, 2011	2
Sunday, August 14, 2011	0
Monday, August 15, 2011	10
Tuesday, August 16, 2011	11
Wednesday, August 17, 2011	12
Thursday, August 18, 2011	5
Friday, August 19, 2011	6
Saturday, August 20, 2011	3
Sunday, August 21, 2011	3
TOTAL	**244**

User Location and Duration

In addition to collecting site visit information, Google Analytics™ also provided the location of visitors and the duration of their visit to the website. This information is summarized in Table 4-5. A total of 243 individual website visits were made over the course of 19 days (note, one additional visit from Jordan, likely made by a WTI staff member on travel, was also made but not included here). While site visits from Montana were the greatest by a large margin, these were made primarily by project staff during the course of routine checks of the site and visits by general WTI staff that were also sent the website link. Consequently, visits from states such as Washington, California, Oregon and Nevada better represent the intended users of the website. As shown, visits from these states represented the majority of visits to the site aside from Montana. Additional visits from states such as Texas, Colorado and New Mexico, as well as Washington D.C., rounded out the observations.

In terms of duration of visits, the average time spend on the website was 7 minutes and 29 seconds. This indicates that most users spent a fair amount of time on the website becoming familiar with its functions. Of course, this number is somewhat skewed by the visits made from Montana, which did not entirely represent users, but rather, project staff making checks on the site. Excluding Montana visits, the average length of visit was 12 minutes and 54 seconds. This figure further confirms that most users took time to explore the website and its capabilities. (Note: the visit from New York was likely from someone who found the site inadvertently and it was not what they were looking for.)

Table 4-5. Website visits, by duration from Google Analytics™

Region	Visits	Avg. Time on Site (sec)
Montana	121	514.51
Washington	45	424.97
California	32	158.03
Nevada	27	331.77
Oregon	10	587.90
Texas	2	413.00
Colorado	2	367.50
District of Columbia	2	2713.50
New York	1	0.00
New Mexico	1	1197.00

Visits by State

Information was collected regarding not only the general state that each visit originated from, but also the location of each visit. For simplicity, a breakdown of state by state visits is presented by California, Nevada, Oregon and Washington, as these were the states that the One-Stop Shop website was developed to cover. Locational visit information is presented in Table 4-6, with maps of the access locations provided in Table 4-6 and . Note that much of the Caltrans traffic registers as "Sacramento" despite originating from various locations in the state. For instance, use in District 2 in Redding will still show Sacramento as the location. Similarly, use from ODOT users may register as "Salem" regardless of the location of the user at DOT facilities in Oregon.

Table 4-6. Website visits, by location from Google Analytics™

California		
City	**Visits**	**Avg. Time on Site**
Sacramento	21	174.4762
San Francisco	10	126.9
Davis	1	124
Nevada		
City	**Visits**	**Avg. Time on Site**
Carson City	16	456.4375
Reno	9	183.8889
Gardnerville	2	0
Oregon		
City	**Visits**	**Avg. Time on Site**
Salem	10	587.9
Washington		
City	**Visits**	**Avg. Time on Site**
Olympia	15	726
Wenatchee	9	101.6667
Mountlake Terrace	8	441.875
Seattle	5	61
Spokane	2	550.5
Tumwater	2	499
Ellensburg	2	272
Moses Lake	1	0
Bellingham	1	836

Figure 4-6. Locations of website access from Google Analytics™

Website Access and Compatibility

Developing a website which was compatible with multiple browsers (and different versions of them) was a goal of this project. To this end, different usage statistics pertaining to various aspects of browsers, operating systems and display resolution are presented in the following tables.

Table 4-7. Browser statistics from Google Analytics™

Browser	Visits	Percentage
Internet Explorer	118	0.483607
Firefox	69	0.282787
Chrome	21	0.086066
Safari	20	0.081967
Opera	11	0.045082
Android Browser	5	0.020492

Table 4-8. Browser version statistics from Google Analytics™

Internet Explorer Versions:		
Browser Version	**Visits**	**Percentage**
8	60	0.508475
7	51	0.432203
9	5	0.042373
6	2	0.016949
Firefox Versions:		
Browser Version	**Visits**	**Percentage**
5.0	28	0.405797
5.0.1	25	0.362319
3.6.18	6	0.086957
3.6.20	4	0.057971
4.0	3	0.043478
3.6.17	1	0.014493
4.0.1	1	0.014493
6.0	1	0.014493
Chrome Versions:		
Browser Version	**Visits**	**Percentage**
13.0.782.107	14	0.666667
12.0.742.122	3	0.142857
13.0.782.112	3	0.142857
12.0.742.112	1	0.047619
Safari Versions:		
Browser Version	**Visits**	**Percentage**
6533.18.5	15	0.75
534.5	3	0.15
532.2	1	0.05
534.8	1	0.05
Opera Versions:		
Browser Version	**Visits**	**Percentage**
11.5	11	1

Table 4-9. Operating systems from Google Analytics™

Operating System	Visits	Percentage
Windows	215	0.881148
iPad	13	0.053279
Macintosh	6	0.02459
Android	5	0.020492
(not set)	2	0.008197
iPhone	2	0.008197
Linux	1	0.004098

Table 4-10. Browsers and operating systems from Google Analytics™

Browser and OS	Visits	Percentage
Internet Explorer / Windows	118	0.483607
Firefox / Windows	64	0.262295
Chrome / Windows	19	0.077869
Safari / iPad	13	0.053279
Opera / Windows	11	0.045082
Android Browser / Android	5	0.020492
Firefox / Macintosh	4	0.016393
Safari / Windows	3	0.012295
Chrome / Macintosh	2	0.008197
Safari / (not set)	2	0.008197
Safari / iPhone	2	0.008197
Firefox / Linux	1	0.004098

Table 4-11. Screen resolutions from Google Analytics™

Screen Resolution	Visits	Percentage
1280x1024	105	0.430328
1680x1050	46	0.188525
1024x768	21	0.086066
768x1024	13	0.053279
1920x1080	10	0.040984
1440x900	8	0.032787
1280x800	6	0.02459
1600x1024	5	0.020492
1920x1200	5	0.020492
1152x720	3	0.012295
320x480	3	0.012295
800x1220	3	0.012295
1366x768	2	0.008197
1600x1200	2	0.008197
0x0	1	0.004098
1024x600	1	0.004098
1024x819	1	0.004098
1120x700	1	0.004098
1192x670	1	0.004098
1280x768	1	0.004098
1536x864	1	0.004098
1600x900	1	0.004098
1613x1008	1	0.004098
2560x1600	1	0.004098
480x360	1	0.004098
800x1183	1	0.004098

Marker Event Selections

Of interest to this work was determining what data visitors were most interested in. To this end, the individual marker events (these events being individual points, i.e. an individual CCTV location/image) selected by users for viewing were tracked by Google Analytics™, with the results presented in Table 4-12. As indicated, CCTV images were the greatest items of interest to visitors, which was not entirely surprising. Past observations by Caltrans District 2 staff have found that this feature is the most popular selection on their website as well. Air temperature, incident information and changeable message sign text were also frequently selected by visitors. It is surprising that weather information was not more widely selected by users, although given that the viewing period was during the summer when weather is less of a concern in the west, which may be a partial explanation. Further, many of the weather layers use icons/markers that indicate the sensor reading / forecast value directly, and do not require a click to see further detail. CCTV images, as well as other layers such as Incidents and CMS require the user to click the icon to see further detail beyond location.

Table 4-12. Marker event selections from Google Analytics™

Event Action	Total Events
CCTV	394
Air Temperature (current)	166
Incidents	158
CMS	157
Road Information	89
Clarus Stations	33
Features of Interest	20
Summits	15
Chain Control	14
Wind (current)	8
Rest Areas	5
Truck Scales	4
Humidity (current)	3
Precip 1hr (current)	3
Precip 24hr (current)	3
Weather (forecast)	2

Layer Event Selections

Based on the marker event selections, it was of interest to determine how many individual layer events (layer events represent the collective group of a data element selected, i.e. the selection of all CCTV sites, etc.) were selected. The results for each layer event are presented in Table 4-13. When examining layer event selection, the individual data elements selected, similar results to the marker event selections were observed. Once again, CCTV images were the most commonly selected element, although incident data and road information (each by individual sites) were selected nearly as often. Temperature and wind speed information were the most commonly selected weather data elements, which makes sense given that these are often the weather aspects of greatest interest to most people. In general, the remaining layer events selected by users varied, underscoring the exploratory approach most visitors took to becoming familiar with the site and its capabilities.

Table 4-13. Layer event selections from Google Analytics™

Event Action	Total Events
CCTV	76
Incidents	67
Road Information	62
CMS	61
Air Temperature (current)	48
Temperature (forecast)	36
Wind Speed (forecast)	34
Clarus Stations	26
Features of Interest	23
Rest Areas	23
Chain Control	22
Wind Gust (forecast)	22
Wind (current)	21
Weather (forecast)	20
Pop 12 (forecast)	18
Humidity (current)	17
Precipitation 1hr (current)	16
AHPS	14
Sky Cover (forecast)	13
Snow (forecast)	13
Truck Scales	13
Precipitation Amount (forecast)	12
Summits	12
Precip 24hr (current)	8
Relative Humidity (forecast)	8

Summary

Based on the user survey results and data provided by Google Analytics™, it appears that the website has been well examined and received by users. Of course, the limited sample size of survey results collected from users means that no firm conclusions can be drawn, but the initial feedback received has been positive and also provided useful insights into improvements and modifications that can be pursued in future work. With respect to user feedback, future surveys should target the goods movement/trucking industry and law enforcement user groups, as no responses were obtained from these during the present project. The information provided by Google Analytics™ indicates that the system was viewed by a number of users from a number of different areas in the study region, with most users remaining on the site for an extended period of time.

Chapter 5 Conclusion

One of the primary items of interest to travelers on the nation's roads, particularly those who will be traveling long distances, is the weather they will encounter en-route. While existing real-time traveler information services provide some weather and other information to travelers, the breadth and depth of useful information currently offered is limited. Real-time traveler weather information is a valuable tool in maintaining and enhancing both traveler safety and mobility. From a safety perspective, it is important for travelers to know before a trip about potential challenges that may impact their travel, including snow, ice, high winds, fires and other hazards that may degrade mobility. While such information may currently be available through a variety of sources, there is inconsistency in the types and quality of information available. In addition, the information is generally scattered over numerous web-based (and sometimes non-web-based) sources, meaning travelers must spend significant amounts of time assembling this information before making a trip.

To address the shortcomings of current web-based weather information sources for travelers (and DOT personnel), this project has developed a website displaying multi-state *Clarus* ESS data, along with other information streams as available, such as DOT Intelligent Transportation System (ITS) field elements, CCTV, planned and active closures, incidents, weather sensor readings from non-DOT sources, National Weather Service forecast information, etc. The objective of this project was to integrate a variety of real-time information together in a single web-based location and in a user-friendly format. The region covered by this work includes all of California, Oregon, Washington and Nevada. The developed product displays weather information for this region in a manner that is easily accessed and understood by users. In addition to weather information, the product displays other data streams as available. As a result of this work, the use and presentation of *Clarus* data across multiple states in conjunction with other traveler information streams is demonstrated by providing travelers and agency personnel with a useful planning and management mechanism.

Conclusions

This project has developed a website that provides *Clarus* ESS data, as well as other traveler information data in one location. The One-Stop Shop that was developed addresses a present shortcoming in traveler information by providing travelers with a centralized location to view different data streams that do not conform to jurisdictions (i.e. state line) boundaries. Consequently, the opportunity to provide travelers with comprehensive information for a trip from origin to destination (at least in California, Nevada, Oregon and Washington) and across state and jurisdictional boundaries has been demonstrated.

In developing the One-Stop Shop prototype, the researchers completed a number of specific tasks. This included the development of Concept of Operations and Requirements documents. The Concept of Operations established that the One-Stop Shop website would allow users to do. The Requirements document described what the website should do to accomplish its intended functions.

Development of the website presented a number of challenges including implementing effective visual representations of the associated information and efficient server- and client-side coding to present a smooth, intuitive interface to users. There remain a number of challenges for subsequent development including optimization of code to support a greater number of prospective users and implementation for further interface elements, particularly to enhance the route planner. An additional display, perhaps in tabular or graph form should accompany the route planner to provide a linear representation of the layer elements that would be encountered along the route. In conjunction, further investigation may be given to handling the temporal aspect of travel, although travel time estimation has been deliberately avoided so-as to leave the choice of if and how a route may be traversed to the user.

Based on the user survey results and data provided by Google Analytics™, it appears that the website has been well examined and received by users. Of course, the limited sample size of survey results collected from users means that no firm conclusions can be drawn, but the initial feedback received has been positive and also provided useful insights into improvements and modifications that can be pursued in future work. With respect to user feedback, future surveys should target the goods movement/trucking industry and law enforcement user groups, as no responses were obtained from these during the present project. The information provided by Google Analytics™ indicates that the system was viewed by a number of users from a number of different areas in the study region, with most users remaining on the site for an extended period of time.

Based on the work completed during this project, a mechanism to provide travelers with comprehensive weather and highway information across state and jurisdictional boundaries was demonstrated. The prototype website provides travelers in rural areas have a comprehensive source of information available to them for the planning of their trip. The availability of this information in one location will save travelers time in planning their trip, as well as will help make that trip more safely and with a minimum of delay.

Recommendations

The primary recommendation of this work is that additional One-Stop Shop website development is necessary through future project phases. The purpose of this work was to build a foundation for the overall website with respect to weather and traveler information data streams, content and function. Based on this foundation, the work of future phases should center on refinement of that prototype, the addition of new data streams, and a follow-up evaluation by various user groups. Finally, mechanisms such as Google Analytics™ should continue to be employed in monitoring the use and usability of the site.

As the One-Stop Shop is likely to be of interest and utility to travelers throughout the U.S., future work should examine the necessary steps for expanding the One-Stop Shop prototype beyond the four states now covered. Expansion should also investigate the acquisition of data streams where they presently may exist in the current states covered. For example, Nevada had limited data streams available throughout the state, but these should/will be incorporated as they become available.

Finally, during a future project phase, it would be beneficial to obtain feedback from users regarding the One-Stop Shop website. Specifically of interest to this work would be feedback on the website from user groups that did not view the website during the course of this project (police and goods movement). Aside from obtaining feedback from these groups, the user survey completed during the

course of this project had a limited sample size (13 respondents). Consequently, a future survey should seek to obtain a larger sample size, although the methods available to "spread the word" about the website to the public may be limited (ex. no funding available for advertising, etc.). Therefore, approaches to obtaining a representative sample of user input and feedback will need to be carefully considered.

References

1.) Western Transportation Institute. "WeatherShare Phase 2 Demonstration," April 2010. Available at: http://www.weathershare.org/.

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3.) Western Transportation Institute. "One Stop Shop for Traveler Information," April 2010. Available at: http://oss.weathershare.org/.

4.) Veneziano, David and Douglas Galarus. *Western States One-Stop Shop for Rural Traveler Information: System Concept Document*. Western Transportation Institute, November 2010. Available at: http://www.westernstates.org/Projects/OSS/Clarus/Documents/Clarus%20System%20Concept_Final%201-21-11.pdf

5.) Veneziano, David and Douglas Galarus. *Western States One-Stop Shop for Rural Traveler Information: Requirements Document*. Western Transportation Institute, November 2010. Available at: http://www.westernstates.org/Projects/OSS/Clarus/Documents/Clarus%20Requirements%201-21-2011%20FINAL.pdf

APPENDIX A. List of Acronyms

AHPS – Advanced Hydrologic Prediction Service

Caltrans – California Department of Transportation

CCTV – Closed Circuit Television

CMS – Changeable Message Sign

DOT – Department of Transportation

ESS – Environmental Sensor Station

GIS – Geographic Information System

HAR – Highway Advisory Radio

ITS – Intelligent Transportation Systems

NDFD – National Digital Forecast Database

NDOT –Nevada Department of Transportation

NWS – National Weather Service

ODOT – Oregon Department of Transportation

OSS – One-Stop Shop

PDT – Pacific Daylight Time

RWIS - Road Weather Information System

TMC – Transportation Management Center

WSDOT – Washington State Department of Transportation

APPENDIX B. User Survey Instrument

Western States One-Stop Shop for Rural Traveler Information Prototype Website User Survey

This survey is being undertaken by the Western Transportation Institute, Montana State University, and is sponsored by the Federal Highway Administration, to obtain information about your use of the Western States One-Stop Shop for Rural Traveler Information prototype website.

If you would like to participate, please take a few minutes and answer the questions below. This survey is estimated to take between 5 and 10 minutes to complete. You may provide this prototype website and survey to others in your agency / organization for review and comment. Participation is voluntary. You can choose to not answer any question that you do not want to answer, and you can stop at any time. Note: You must be over the age of 18 to participate in this survey.

Your contact information will only be used by the researchers for the purposes of this study. The researchers will not contact you for any other reason and your contact information will not be released or shared for any other reason. If you have any questions about the survey, please contact WTI at dgalarus@coe.montana.edu or call (406) 994-5268. If you have any questions concerning your rights as a human subject and/or the use of your contact information, please contact:

Institutional Review Board
Montana State University
P.O. Box 173610
Bozeman, MT 59717-3610
Phone: (406) 994-6783
Fax: (406) 994-4303

Survey directions
In order to progress through this survey, please use the navigation links presented on the survey pages:
- Use the Next button to continue to the next page.
- Use the Previous button to return to the previous page.
- Use the Exit the Survey link to exit the survey.
- Use the Submit button on the last page to submit your survey responses.

Note: Clicking the Back button in your browser before a page is completed will clear all data entered on the current page. You may not leave a survey session and start up again where you left off.

Please click the Next button to proceed to the survey:

1. How often will/do you visit the One Stop Shop (OSS) website for information?

- ○ First time visitor
- ○ Website is open all the time
- ○ Hourly
- ○ Daily
- ○ Weekly
- ○ Monthly

Other (please specify)

2. When/why will/do you use (or intend to use) the information? (Check all that are applicable.)

- ☐ Trip planning
- ☐ Under changing conditions only
- ☐ During incident conditions (storm/fire etc)
- ☐ Daytime hours
- ☐ Nighttime hours

Other (please specify)

3. Now we would like you to rate the usefulness of Current Weather data on the OSS website that you have used at least once. For each feature that you have not used, please indicate whether you were aware of this feature before taking this survey. (Please make a single selection for each data element.)

	Very Useful	Somewhat Useful	Not Very Useful	Aware of it	Not Aware of it
Air Temperature	○	○	○	○	○
Relative Humidity	○	○	○	○	○
1-Hour Precipitation	○	○	○	○	○
24-Hour Precipitation	○	○	○	○	○
AHPS 24-Hour Precipitation	○	○	○	○	○
Wind	○	○	○	○	○
Clarus Stations	○	○	○	○	○

4. Please rate the usefulness of Forecast Weather data on the OSS website that you have used at least once. For each feature that you have not used, please indicate whether you were aware of this feature before taking this survey. (Please make a single selection for each data element.)

	Very Useful	Somewhat Useful	Not Very Useful	Aware of it	Not Aware of it
Air Temperature	○	○	○	○	○
Wind Speed	○	○	○	○	○
Wind Gust Speed	○	○	○	○	○
Humidity	○	○	○	○	○
Sky Cover	○	○	○	○	○
12-Hour Chance of Precipitation	○	○	○	○	○
6-Hour Precipitation	○	○	○	○	○
Snow	○	○	○	○	○
Weather	○	○	○	○	○

5. Now we would like you to rate the usefulness of the Road/Travel Conditions data on the OSS website that you have used at least once. For each feature that you have not used, please indicate whether you were aware of this feature before taking this survey. (Please make a single selection for each data element.)

	Very Useful	Somewhat Useful	Not Very Useful	Aware of it	Not Aware of it
Chain Requirements	○	○	○	○	○
Road Information	○	○	○	○	○
Incidents	○	○	○	○	○
Changeable Message Sign Text	○	○	○	○	○
CCTV Images	○	○	○	○	○

6. Please rate the usefulness of the Other Traveler Information data on the OSS website that you have used at least once. For each feature that you have not used, please indicate whether you were aware of this feature before taking this survey. (Please make a single selection for each data element.)

	Very Useful	Somewhat Useful	Not Very Useful	Aware of it	Not Aware of it
Rest Areas	○	○	○	○	○
Features of Interest	○	○	○	○	○
Truck Scales	○	○	○	○	○
Summit Locations	○	○	○	○	○

7. Now we would like you to rate the usefulness of the features on the website that you have used at least once. For each feature that you have not used, please indicate whether you were aware of this feature before taking this survey (Please make a single selection for each feature.)

	Very Useful	Somewhat Useful	Not Very Useful	Aware of it	Not Aware of it
Route Planner	○	○	○	○	○
Google Map Display & Zoom Function	○	○	○	○	○
Google Terrain	○	○	○	○	○
Google Satellite Imagery	○	○	○	○	○

8. Based on your experience using the website, please evaluate the site in terms of the following aspects – indicate your level of agreement with these statements.

	Strongly Agree	Somewhat Agree	Neither Agree nor Disagree	Somewhat Disagree	Strongly Disagree
The site is well organized and user friendly.	○	○	○	○	○
The site presents the right amount of information.	○	○	○	○	○
I would like to see additional information added.	○	○	○	○	○
I would like to see less information presented.	○	○	○	○	○
Information should be presented in a different format than the current one.	○	○	○	○	○
I find the information presented timely and useful.	○	○	○	○	○
I find the information presented accurate and understandable.	○	○	○	○	○

9. What additional information, if any, would you like to have, which is not available currently at this site? (Please specify the type, format, frequency of updating, and accuracy of data, if applicable.)

10. What are the chief benefits of this website to you in the context of your current usage? Please be as specific as possible.

11. Please also indicate how this website could be improved to better meet your needs. Consider information content, ease of use of the site, ability to understand what is presented and anything else that could make this site better.

12. User category:

- ○ General public/traveler
- ○ Transportation professional (ex. DOT)
- ○ Goods movement/commercial trucking
- ○ Law enforcement

Other (please specify)

13. (OPTIONAL) Please enter your contact information (Note: information will be kept private/confidential and will be used for study purposes only).

Name

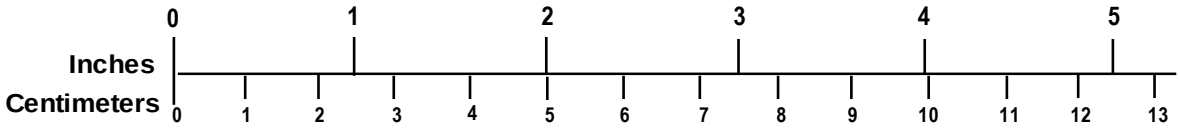
Location (state)

Email

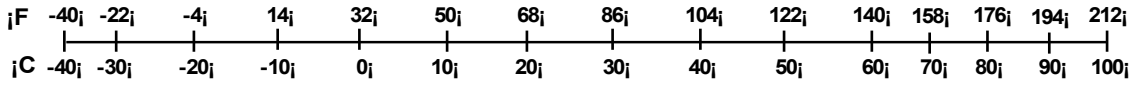
APPENDIX C. Metric/English Conversion Factors

ENGLISH TO METRIC		METRIC TO ENGLISH	
LENGTH (APPROXIMATE)		**LENGTH (APPROXIMATE)**	
1 inch (in)	= 2.5 centimeters (cm)	1 millimeter (mm)	= 0.04 inch (in)
1 foot (ft)	= 30 centimeters (cm)	1 centimeter (cm)	= 0.4 inch (in)
1 yard (yd)	= 0.9 meter (m)	1 meter (m)	= 3.3 feet (ft)
1 mile (mi)	= 1.6 kilometers (km)	1 meter (m)	= 1.1 yards (yd)
		1 kilometer (km)	= 0.6 mile (mi)
AREA (APPROXIMATE)		**AREA (APPROXIMATE)**	
1 square inch (sq in, in^2)	= 6.5 square centimeters (cm^2)	1 square centimeter (cm^2)	= 0.16 square inch (sq in, in^2)
1 square foot (sq ft, ft^2)	= 0.09 square meter (m^2)	1 square meter (m^2)	= 1.2 square yards (sq yd, yd^2)
1 square yard (sq yd, yd^2)	= 0.8 square meter (m^2)	1 square kilometer (km^2)	= 0.4 square mile (sq mi, mi^2)
1 square mile (sq mi, mi^2)	= 2.6 square kilometers (km^2)	10,000 square meters (m^2)	= 1 hectare (ha) = 2.5 acres
1 acre = 0.4 hectare (he)	= 4,000 square meters (m^2)		
MASS - WEIGHT (APPROXIMATE)		**MASS - WEIGHT (APPROXIMATE)**	
1 ounce (oz)	= 28 grams (gm)	1 gram (gm)	= 0.036 ounce (oz)
1 pound (lb)	= 0.45 kilogram (kg)	1 kilogram (kg)	= 2.2 pounds (lb)
1 short ton = 2,000 pounds (lb)	= 0.9 tonne (t)	1 tonne (t)	= 1,000 kilograms (kg)
			= 1.1 short tons
VOLUME (APPROXIMATE)		**VOLUME (APPROXIMATE)**	
1 teaspoon (tsp)	= 5 milliliters (ml)	1 milliliter (ml)	= 0.03 fluid ounce (fl oz)
1 tablespoon (tbsp)	= 15 milliliters (ml)	1 liter (l)	= 2.1 pints (pt)
1 fluid ounce (fl oz)	= 30 milliliters (ml)	1 liter (l)	= 1.06 quarts (qt)
1 cup (c)	= 0.24 liter (l)	1 liter (l)	= 0.26 gallon (gal)
1 pint (pt)	= 0.47 liter (l)		
1 quart (qt)	= 0.96 liter (l)		
1 gallon (gal)	= 3.8 liters (l)		
1 cubic foot (cu ft, ft^3)	= 0.03 cubic meter (m^3)	1 cubic meter (m^3)	= 36 cubic feet (cu ft, ft^3)
1 cubic yard (cu yd, yd^3)	= 0.76 cubic meter (m^3)	1 cubic meter (m^3)	= 1.3 cubic yards (cu yd, yd^3)
TEMPERATURE (EXACT)		**TEMPERATURE (EXACT)**	
[(x-32)(5/9)] °F	= y °C	[(9/5) y + 32] °C	= x °F

QUICK INCH - CENTIMETER LENGTH CONVERSION



QUICK FAHRENHEIT - CELSIUS TEMPERATURE CONVERSION



For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50 SD Catalog No. C13 10286

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