Design and Development of an Integrated Web-based System for USGS and AHPS Data Analysis Using Open Source Cyberinfrastructure

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ABSTRACT

Design and Development of an Integrated Web-based System for USGS and AHPS Data Analysis Using Open Source Cyberinfrastructure

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The Gauge Viewer WaterML App is a web application to discover and visualize National Water Information System (NWIS) data collected at United States Geological Survey (USGS) streamflow gauges together with Advanced Hydrologic Prediction Service (AHPS) forecasts provided by the United States National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS). The web application exposes a representational state transfer application programming interface (REST API) that allows data to be downloaded in the WaterML format and be registered as a resource in HydroShare. The software was developed on the open source Tethys Platform, and integrates with other open and closed source cyberinfrastructure. This paper presents the design and development of the Gauge Viewer WaterML Web App with focus on demonstrating a fully web services based Tethys Platform application that consumes and generates web services. This is also the first implementation of a WaterML web service for AHPS. Finally the app presents the first integrated viewer for USGS, AHPS, and forecasts from the National Water Model.

Keywords: USGS streamflow, AHPS forecast, Tethys Platform, web app, HydroShare, National Water Model, web services

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1 INTRODUCTION

Hydraulic and hydrologic data are continuously generated for many parameters in locations throughout the world. These data can be extremely useful to watershed managers, researchers, and interested members of the public for use in water planning, emergency management, and hydrologic science. The vast amounts of data being continuously generated make it difficult for researchers to find appropriate, up to date data [Horsburgh et al., 2009]. When appropriate data is found for a particular need there is still a substantial amount of effort required to properly format data for analysis or modeling. The process of transforming data into the appropriate format for use can require significant amounts of time [Goodall et al., 2008].

This project presents the design and development of Gauge Viewer WaterML, a water resources web application built using the Tethys Platform. Gauge Viewer WaterML integrates multiple open source tools and data sources to demonstrate the ability to integrate existing cyberinfrastructure with multiple existing web services to more easily find, visualize, and begin analysis of data. This developed software tool serves as an example of how existing cyberinfrastructure can be linked together to assist researchers and other interested parties in data acquisition and preliminary analysis. The approaches and techniques used here are expected to provide future water data scientists with a model for integrating web services to create new useful tools and functionality on the web.

1.1 Water Resources Cyberinfrastructure

Cyberinfrastructure includes the technology that is used to efficiently manage, store, and share data [Horsburgh et al., 2009]. Cyberinfrastructure is important for integrating essential components of scientific research, including making data available to duplicate research results and draw new conclusions [Atkins, 2003]. A robust cyberinfrastructure helps lessen technological barriers of entry for new scientists and for organizations to collaborate with established entities, often sharing data and results across traditional disciplinary boundaries [Ramdeen, 2013]. This is especially true of open source additions to the cyberinfrastructure, which are generally focused on implementing key capabilities for existing and foreseeable needs [Richard et al., 2014].

Within the water resources and earth sciences community, a continuously growing cyberinfrastructure is available for accessing, sharing, viewing, and analyzing data [Richard et al., 2014]. In the United States, much of the publicly available water data are created by government entities, such as the United States Geological Survey (USGS), while other data are generated by researchers from universities and elsewhere. Online water resources datasets are provided in large number of widely differing formats, including: custom formatted ASCII text files, NetCDF files, proprietary binary format files, and in online viewers. The Open Water Data Initiative (OWDI) in the United States began in 2014 with the purpose of opening water data services to best use water data in relation to flooding, water supply and water quality [Maidment, 2016]. The OWDI requires that government agencies publish available water data, and will also partner with smaller data providers to provide access to even more data [Larsen et al., 2016]. The benefits of federal agencies publishing data with standardized formats and methods include reducing the need for agency personnel to directly be involved in routine data inquiries or

Freedom of Information Act (FOIA) requests, because the data is already available for anyone to access.

1.2 CUAHSI HIS

The Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI) was founded in 2001 as a research infrastructure initiative to use resources available from over 100 member institutions and partners resources to address key hydrologic questions [Wilson et al., 2005]. CUAHSI receives grants from the National Science Foundation (NSF) to further hydrologic science research, including several open source projects. Much of CUAHSI's cyberinfrastructure research is under the umbrella of the CUAHSI Hydrologic Information Systems (HIS) program, which has included development of many components which each provide specific capabilities for better handling and understanding hydrologic data [Ames et al., 2009]. The components of the CUAHSI HIS program are continuously being refined, updated, and developed, to further meet the growing demands of data storage, retrieval, and analysis, while utilizing upgraded technology resources that are continuously being developed.

The CUAHSI HIS program has produced many important components of the current hydrologic cyberinfrastructure, including the standardized file transfer format WaterML, which preserves metadata as well as observation information [Valentine and Zaslavsky, 2009], and HydroShare, a web-based hub to store and share many types of data [Tarboton et al., 2014]. One additional cyberinfrastructure component of note for this project is the Tethys Platform [*Swain et al.*, 2014]. Each of these three components will be discussed following.

WaterML was developed by CUASHI for the purpose of defining message formatting for return information sent from WaterOneFlow web services [Zaslavsky et al., 2007].

WaterOneFlow web services were developed by CUAHSI to allow for data transfer from an online source [Zaslavsky et al., 2007], and are a part of the CUAHSI HIS. WaterOneFlow web services were introduced to standardize requests made to different servers for data retrieval, without requiring the back end of servers to implement significant changes [Whiteaker and To, 2008]. WaterML "encode[s] the semantics of hydrologic observation discovery and retrieval and implement water data services in a way that is both generic and unambiguous across different data providers…" [Valentine and Zaslavsky, 2009]. The WaterML format was adopted and implemented by the USGS National Water Information System (NWIS) Daily Values web service. The adoption of the WaterML format by the USGS gave a significant boost to the use of WaterML, and it is under consideration for adoption by other government agencies as well [Zaslavsky et al., 2009].

In this project WaterML version 1.1 is used, which contains updated schema and information based on user experience from version 1.0 [Zaslavsky et al., 2009], and is currently more widely used than WaterML 2. WaterML 2 has been accepted by the Open Geospatial Consortium (OGC), an international standards agency, as a standard [WaterML, 2014]. This recognition has lifted the profile of the standard above the status received by version 1.1 due to harmonizing information from multiple different OGC standards into the reformulated standard [Khattar and Ames, 2014]. WaterML 2.0 is very different from WaterML 1.1 due to the integration of other standards to promote acceptancy by the OGC.

1.3 HydroShare

HydroShare is a collaborative system first released in 2014 to facilitate the sharing of hydrologic data and models through an online service [Tarboton et al., 2014]. HydroShare contains the ability to store data, perform computations, and host applications [Heard et al., 2014]. One of the purposes behind HydroShare is to make diverse datasets and models “social objects” which can easily be published, cataloged, annotated, and discovered [Horsburgh et al., 2015]. HydroShare hosts “resources” that may contain many different file types, consisting of datasets, models, or results. Resources may contain time series observational data, geographic shapefiles, gridded geographic data, or other more complex data and model information [Horsburgh et al., 2015]. HydroShare provides access to the geospatial metadata of a resource to discover, visualize, and process data [Heard et al., 2014].

Development of HydroShare is open source, with all source code hosted on GitHub and accessible for anyone to review and assist in the development of. The development of HydroShare is supported by National Science Foundation collaborative grants [Horsburgh et al., 2015] and development is primarily from the efforts of eight universities, CUASHI, and the Renaissance Computing Institute (RENCI) [Tarboton et al., 2014]. Further developments to HydroShare are expected increase the capacity to efficiently share datasets and interface with computational resources to run models and reproduce results in the web based environment [Horsburgh et al., 2015].

1.4 Tethys Platform

The Tethys Platform provides a suite of free and open source software (FOSS) which addresses unique needs of water resources data and computation [*N Swain et al.*, 2015]. One intended use of Tethys Platform is for development of cloud-based applications that individually provide limited modeling functionality for a component of larger analysis workflow [*Swain et al.*, 2014]. Tethys brings together several other FOSS components to provide a robust Python software development kit (SDK) [Jones et al., 2014], which includes the Django Python web framework, allowing for the integration of the Python language with JavaScript and HTML. Combined, these provide a relatively simplified way to create highly functional web applications [*Swain et al.*, 2014]. Tethys was designed in part to enhance access to data [Jones et al., 2014]. Tethys makes available multiple resources for visualization of geospatial data, including OpenLayers and Google Maps, as well as Highcharts for visualization of tabular or time series data. Tethys also provides “gizmos” which are pre-programmed interactive controls which can be easily inserted in web apps to increase usability. Many applications have been built on Tethys demonstrating varied functionality and ability to perform data analysis on geospatial, time series, and tabular datasets (see apps.hydroshare.org).

1.5 Opportunities in Water Resources Cyberinfrastructure

Cyberinfrastructure, specifically web services, have become highly developed in the information systems and information technology fields. Cyberinfrastructure in water resources for accessing uniquely water related data is a relatively new field. The first machine accessible interface for USGS National Water Information System (NWIS) data was released in 2008 [Goodall et al., 2008], at roughly the same time that WaterOneFlow web services were introduced [Whiteaker and To, 2008]. Some cyberinfrastructure related to, but not exclusive to, water resources, such as geographic information systems (GIS), and web map services (WMS), provide essential resources and are fairly well developed.

Due to the relatively recent introduction of cyberinfrastructure, and the rapid pace of new developments, in water resources, there is a lack of tools that utilize and combine web services to make useful end user services. There is a need for web services which demonstrate, specifically for water resource users, how web services can be combined to create a service that adds even more value. There currently exists web services which produce stream discharge forecasts on a regular basis, including forecasts by the National Water Model (NWM) and the United States National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) Advanced Hydrologic Prediction Service (AHPS), but which cannot easily be compared to observed conditions, such as those collected by the USGS streamflow gauge network.

1.6 Research Goals

The goal of this project is to demonstrate how available web services can be synthesized through the creation of a new web service in an efficient manner to make data more readily available and usable. The Gauge Viewer WaterML application shows that existing web services which provide NWM forecasts can be combined with other forecasts and observed conditions for simple comparison by anyone. The development of this project demonstrates that this can be accomplished through a modularized approach, in which data sources can be independently added, and the resulting data can be easily shared through a social web data catalog.

Specifically, the development of the Gauge Viewer WaterML application is to demonstrate the ability to simplify discovery and retrieval of available data from the USGS stream gauge network and the AHPS forecast locations, and provide them as a comparison with NWM forecast output. Discovery is accomplished through the use of an external web map service (WMS), which is viewed through a user interface built on the Tethys Platform. Retrieval of data is accomplished by the exposure of a representational state transfer application programming interface (REST API). A REST API defines functionality based on a set of input parameters. The Gauge Viewer WaterML REST API requires a properly formatted Uniform

Resource Locator (URL), and then retrieves streamflow information from the appropriate source and downloads it in the WaterML format. Data retrieval can be accomplished through use of the user interface, or by directly accessing the API from a browser or scripting environment.

2 METHODS

2.1 Software Development and Design

The software written for this project is built on the Tethys Platform (www.tethysplatform.org) as an open source project, meaning that any individual or company that wants to use the code can do so. Open source software is used by many individuals and there are many resources available to help open source projects be successful. For this project GitHub (www.github.com), which is free to use for open source code development projects, was used as both a code repository and version control system. By using GitHub the risk of equipment failure causing loss of work was greatly minimized. The other clear advantage is that the source code, in its entirety, is available for anyone to find on the internet. One reason that GitHub specifically was chosen as the code repository for this project is that Tethys Platform uses it, as well as many other Tethys apps which are built in the BYU labs.

Because this application has the specific purpose of accessing data that are hosted by USGS and NOAA there is minimal data storage associated with the application. Actual discharge data that can be retrieved by the application is not stored by the application, making deployment of the application much simpler for any user. The only data required to be hosted for the use of the application is a file displaying the location of, and providing minimal information regarding, the USGS and AHPS locations, which can be hosted in any WMS compliant geographic information system (GIS).

This software was built using a REST endpoint to perform essential functions. The endpoint, which will convert data to the WaterML format is called from the user interface to download the data. This endpoint is also used to display data in other applications, and to register data as a resource in HydroShare. The overall software architecture for the Gauge Viewer WaterML app is seen in figure 2.1-1. All functionality listed in figure 2.1-1 preceded by a star (*) was developed by me for this project. Specific functionality and abilities of the application will be discussed in section 3.2.

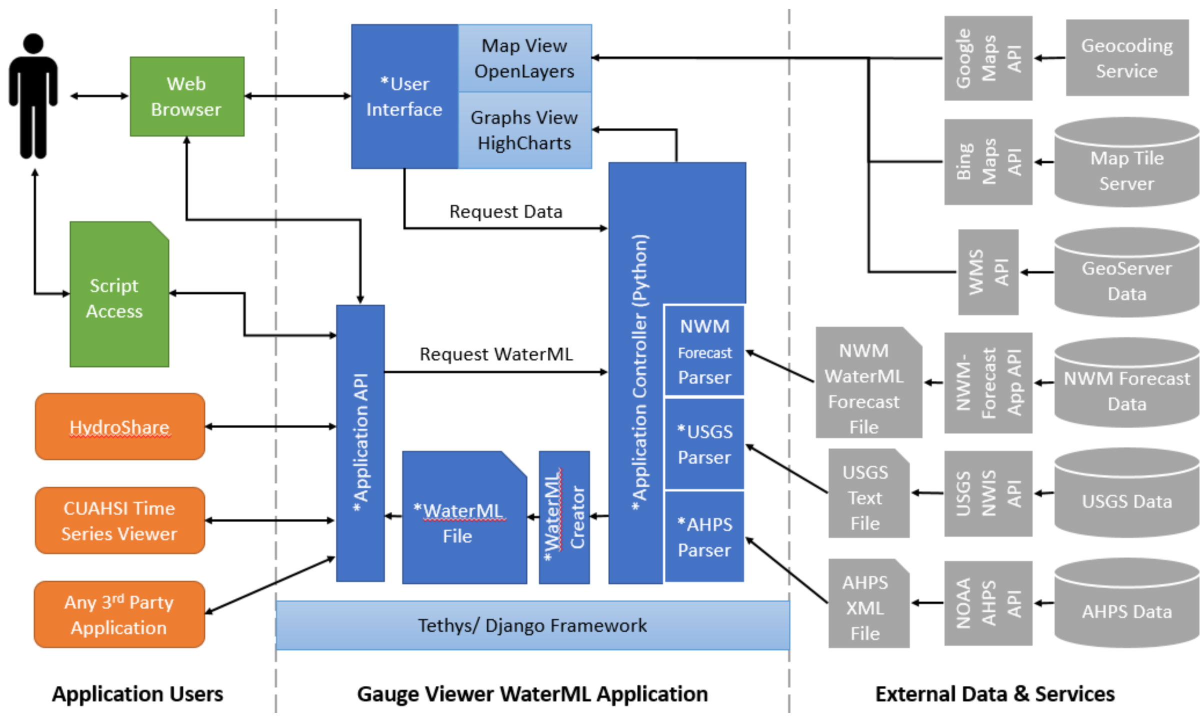

Figure 2.1-1: Gauge Viewer WaterML Architecture Diagram

The user interface for the application is based on the default Tethys styling, and is customized to mirror the interface of existing GIS software, while being greatly simplified from a desktop GIS program. The user interface was designed separately for each page which displays information. The initial user interface includes a large map view component for locating gauges, and can be seen in figure 2.1-2.

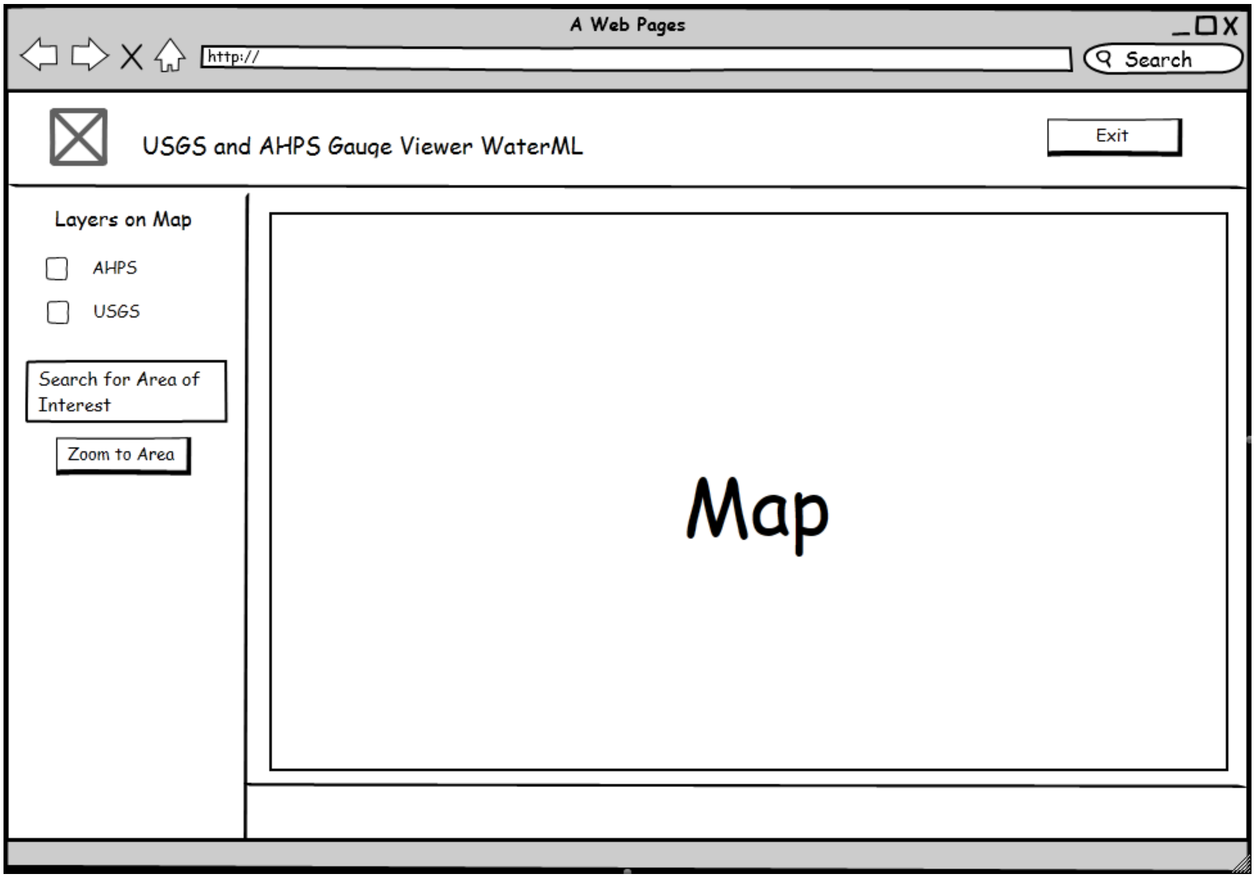

Figure 2.1-2: Main User Interface

As seen in figure 2.1-2, the map view is the primary component of the user interface, while the options to select distinct layers and search for locations of interest make up only a small portion of the interface. The AHPS forecast location information page replaces the map view with large plots of available information, and can be seen in figure 2.1-3.

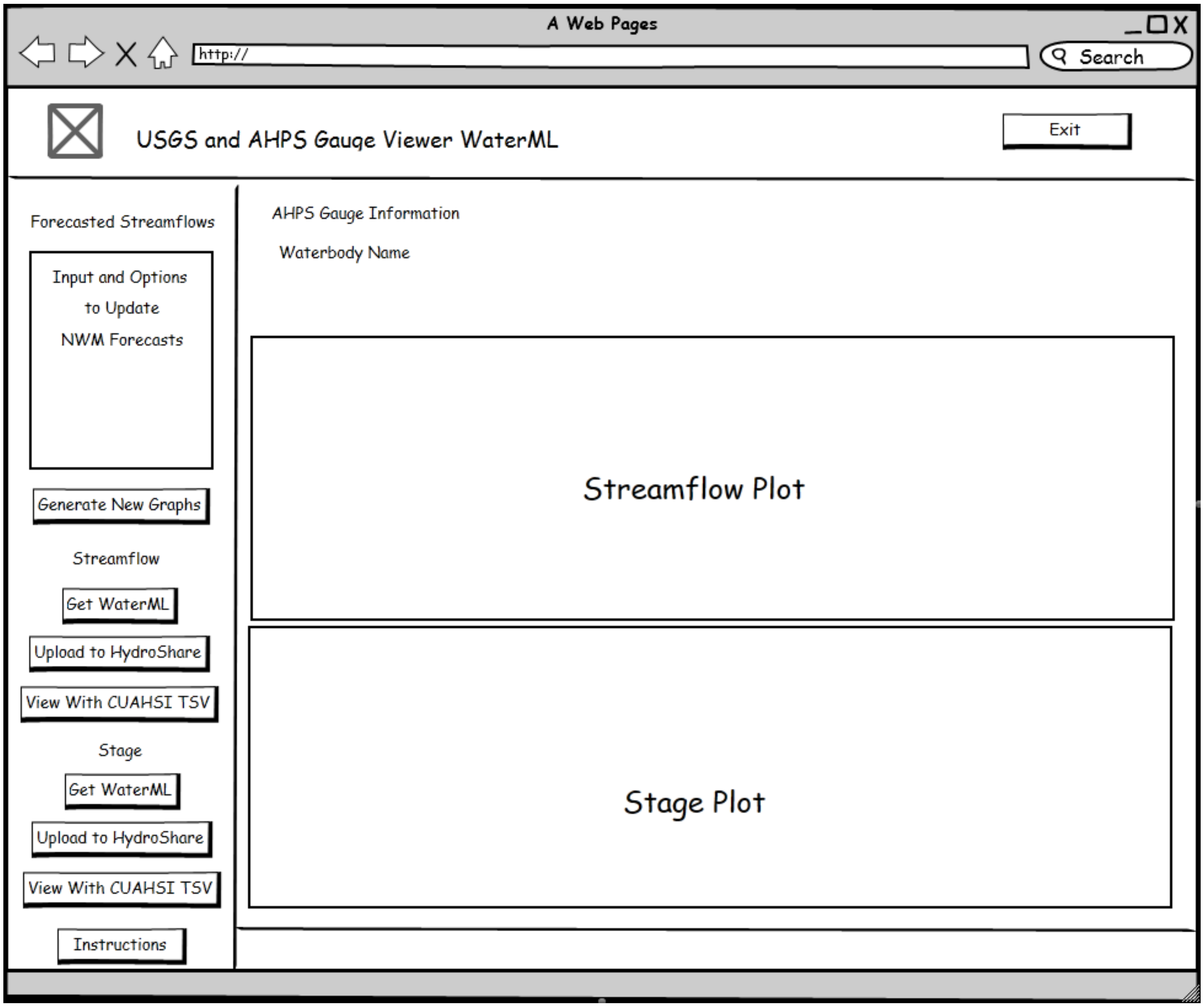

Figure 2.1-3: AHPS Forecast Information User Interface

The AHPS forecast information interface also provides functionality through options on the left side of the screen to compare National Water Model (NWM) forecasts in the plots. NWM forecasts can be added to the plots by selecting the required input on the left and then updating the graphs. Since all available data is displayed there are no options relating to loading different AHPS forecasts.

The USGS gauge location information user interface is very similar to the interface for the AHPS page, with the primary difference being that daily average streamflow values are plotted rather than stage information. The other primary difference is that streamflow information is available for a wide range of times, and thus can be selected through options on the left hand side of the interface. The USGS gauge information page can be seen in figure 2.1-4.

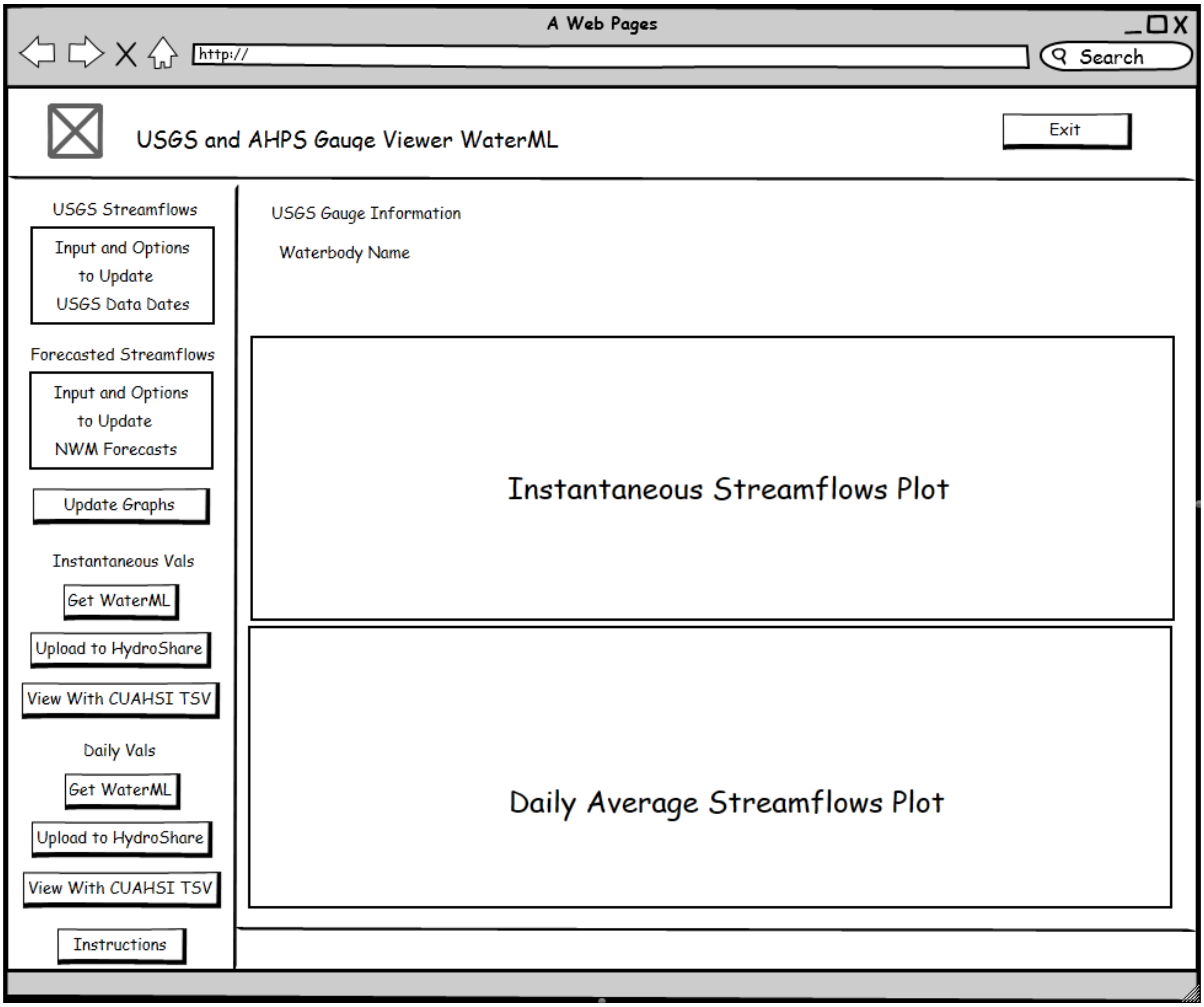

Figure 2.1-4: USGS Gauge Information User Interface

3 RESULTS

3.1 Software Development

The Gauge Viewer WaterML application is hosted at tethys.byu.edu/apps. The application is accessible to anyone with a login at tethys.byu.edu or hydroshare.org. Accounts are free at both locations. There are multiple other apps that are also available at tethys.byu.edu, representing the work of other BYU students. HydroShare also hosts many other apps, some of which were developed by BYU students at apps.hydroshare.org.

The Gauge Viewer WaterML application makes use of OpenLayers (version 3.15.1), which provides a JavaScript API for visualizing spatial data in a browser. OpenLayers has grown in popularity in the last decade, attracting many users and developers [Steiniger and Hunter, 2013]. One major advantage of OpenLayers is that a number of Open Geospatial Consortium (OGC) compliant formats are supported, allowing customization to fit the specific needs of the application [N R Swain et al., 2015]. The OGC has been active for over 20 years in working with data producers and users, including government agencies, academics, and industry to create common standards [Sui, 2014]. The ability of OpenLayers to use multiple standard formats developed by the OGC is one of the key reasons for its popularity and relatively widespread usage.

Integration with other software and applications was essential to how the Gauge Viewer WaterML app was created. The application interfaces with multiple web services as well as other applications. Functionality was added to compare gauge information with past forecasts from the National Water Model (NWM) that are retrieved through the REST API of another web application, the NWM Forecast Viewer. The NWM Forecast Viewer application was also built on the Tethys Platform.

3.2 Capabilities

The Gauge Viewer WaterML application results in a large amount of functionality in a single application. Each page that a user is on includes an instructions pop up which can be consulted to assist in using the functionality of the page. The functionality of the application, through both the user interface and the REST API are further described in this section. The functionality described in this section was specifically developed for this application, unless otherwise indicated.

3.2.1 Search for Gauges by Location

When initially launched, the GaugeViewer WaterML application displays a map with locations of USGS gauges and AHPS forecast points displayed. The points are throughout the United States. In order to show where each gauge is located a web mapping service (WMS) was established on GeoServer, an open source GIS program which is provided as part of the Tethys Platform Software Development Kit (SDK). WMS is an OGC standard [Beaujardiere, 2006] that can be implemented by any GIS, and there are other GIS software that do implement the WMS protocol. The WMS for this application hosts two datasets, one each for USGS and AHPS locations, which were originally retrieved as shapefiles from the respective agencies. The USGS maintains water data at over 1.6 million individual sites throughout the United States. As of July 30, 2016 just over 16,500 sites have information for "current conditions and recent daily data", which is the data displayed by the Gauge Viewer WaterML applicaion by default. [Retrieved from http://waterdata.usgs.gov/nwis/inventory, July 30, 2016]. The AHPS forecast network is comprised of about 3,500 forecast locations, of which 1,800 are active [Retrieved from http://water.weather.gov/ahps/forecasts.php, July 30, 2016]. The WMS initially provides images of all gauge locations which can be displayed on the map. After a gauge location is selected on the map, the WMS provides the gauge location, gauge ID, latitude, and longitude.

The app provides a search bar for users to input an area of interest, which then uses a web based geocoding service through the Google Maps API, which is free to use, closed source software, to zoom the map to the desired area. When a gauge of interest is selected a popup table is generated which allows users to access gauge information within the application, or leave the application and view gauge information on the USGS or NOAA website. The functionality to leave the application for the USGS or NOAA website is intended as a convenience if the user wants to find more information for the gauge than is available from the application. An example of additional functionality not provided by the Gauge Viewer WaterML application is that many USGS gauge locations have water quality measurements, such as suspended sediment concentration, available. The main page of the application can be seen in Figure 3.2.1-1:

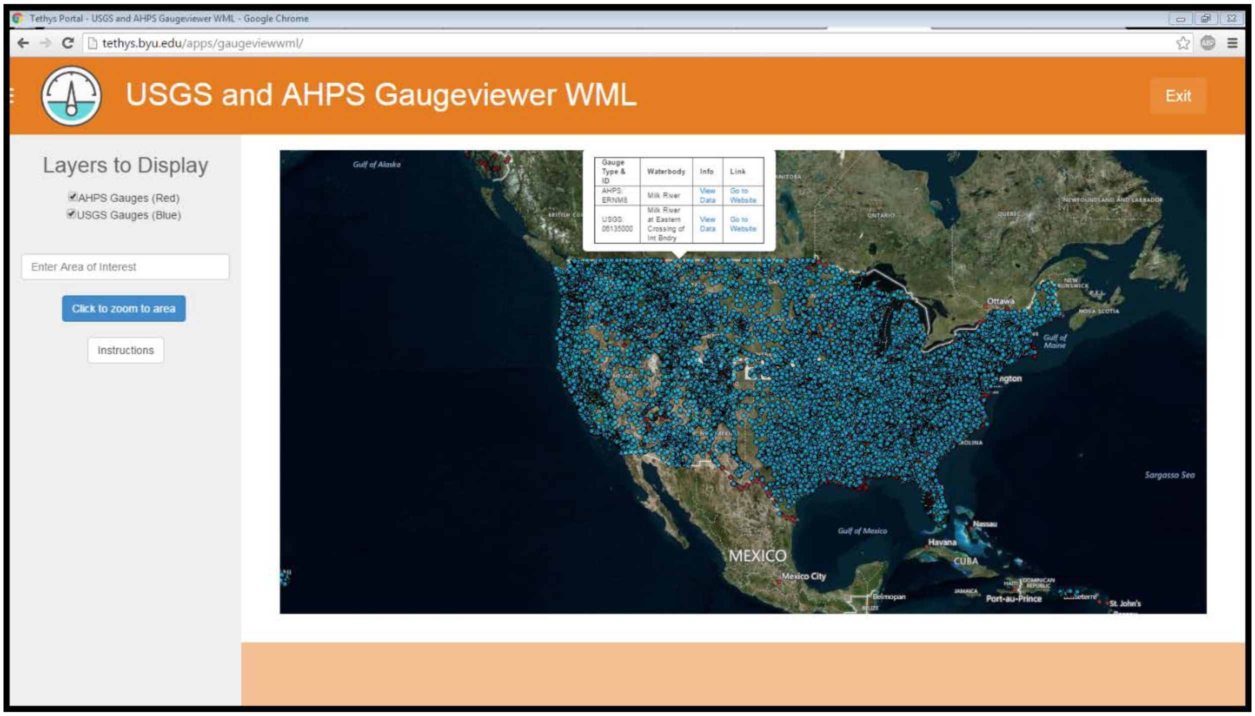

Figure 3.2.1-1: Initial Application View

3.2.2 Retrieve and Display Gauge Information

When a gauge, either USGS or AHPS, is selected, a new browser tab is opened with information regarding the gauge. The Gauge ID and waterbody are shown on every page, again with a link to an external website with more information regarding the gauge.

For AHPS forecast locations all available data are displayed. This is possible because at the longest it extends is roughly a week into the past and future, and so there is at most less than a month of data, which does not require a lot of time to retrieve and display. AHPS data available are discharge and stage height. These two data sources are displayed on separate graphs. Not every AHPS location has stage and discharge information available. Some sites only have one data type. Some sites have observed and forecast data, while other sites only have observed, and still other sites have gone inactive, and do not have updating observations or forecasts. An example of how AHPS forecast information is displayed can be seen in Figure 3.2.2-1.

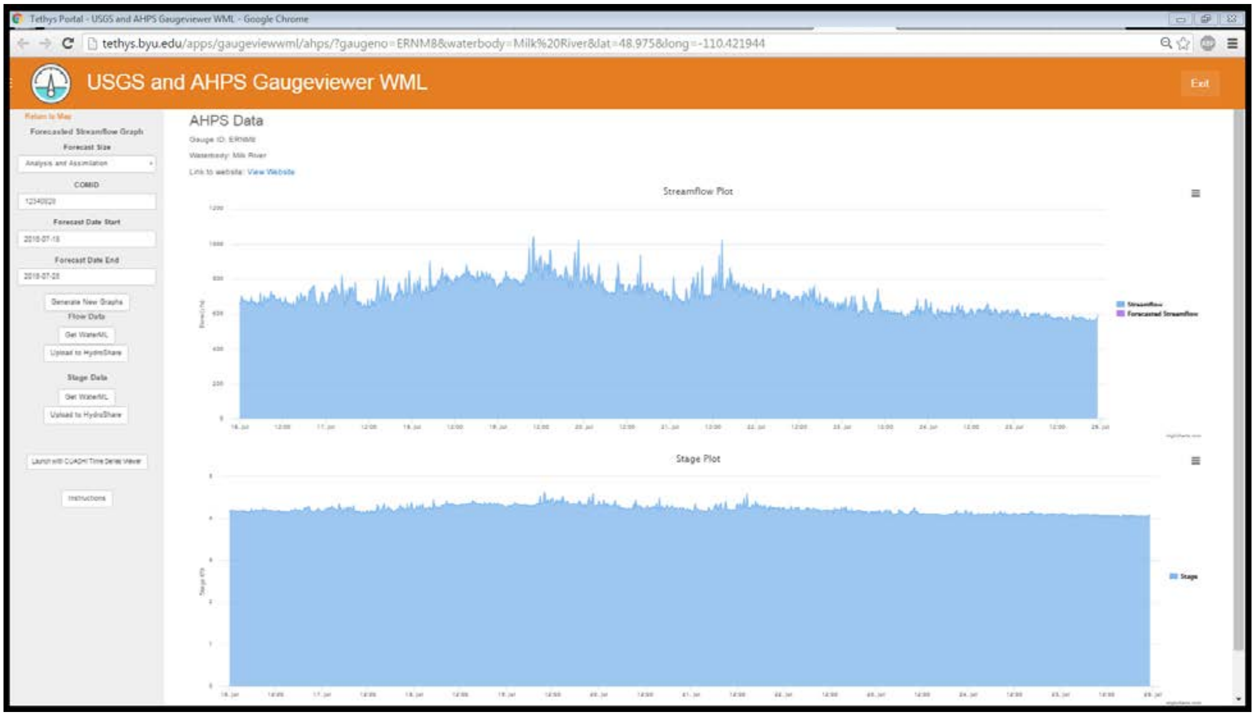

Figure 3.2.2-1: AHPS Data Display

USGS data are initially displayed for the past two weeks. This was chosen because it will help the user to have an up to date look at the conditions of the stream or river of interest, while not taking an extremely long amount of time to load and display. For USGS gauges the instantaneous values (generally measured in 15-minute increments, though it can vary, and be as low as 5-minutes) as well as daily average values are displayed, again on their own graphs. Users may select any date range to view data. Not every USGS gauge is currently actively measuring discharge, and so a site page may launch with no data. In this case a message will be displayed to the user who can then try to view data for an earlier date. These instructions are also available to the user through the instructions pop-up on the page. USGS gauge information being displayed can be seen in Figure 3.2.2-2:

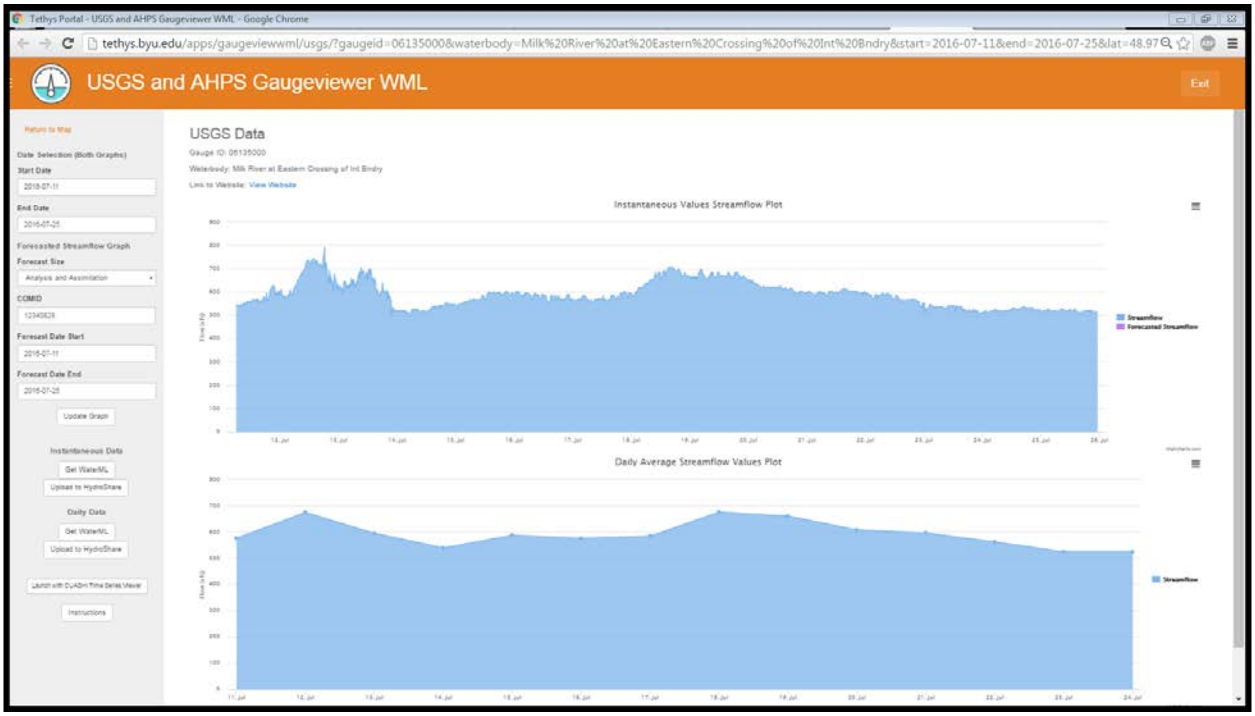

Figure 3.2.2-2: USGS Data Display

3.2.3 Download WaterML Files of Displayed Information

The benefits of WaterML have been previously discussed. Through the application a user can download any displayed gauge information in the WaterML format. This happens in two different ways. The USGS maintains an instantaneous values retrieval web service which will distribute WaterML files based on an appropriately formatted call, which is done in the application for any instantaneous values requests. Daily average streamflow values are not available in WaterML format from the USGS, and so are created based on available data from the USGS by the application. A WaterML 1.1 standard file is returned for each call. AHPS data is not available in the WaterML format, and so it is also generated by the application. The decision to retrieve information from the USGS gauges and AHPS forecast locations and convert them to a new format prior to delivery to the user is not without precedent [Horsburgh et al., 2014] and gives the distinct advantage of allowing users to retrieve a standardized data format which can be read by other applications.

A WaterML file is generated by the application through the use of a REST API. This means that any user can call the appropriate URL and retrieve the data available from the application. This is accomplished through a properly formatted URL being entered. One major advantage of this is that a user can automate, through the use of a script, the retrieval of up to date WaterML files for any gauges of interest, saving significant amounts of time in data collection.

3.2.4 View Displayed Information with the CUAHSI Time Series Viewer

Both AHPS and USGS data can be viewed in the CUAHSI Time Series Viewer. This is an application that has also been developed at BYU, and which is designed to read and display time series information in several formats, including WaterML. The Time Series Viewer application also provides limited, although useful, statistical functionality which is not provided internally by the Gauge Viewer app. Another user advantage to viewing data with the Time Series Viewer is that metadata contained within the WaterML file, above and beyond what is available in the Gauge Viewer app, is extracted and displayed. The Time Series Viewer also allows multiple files to be displayed on the same graph, thus allowing for easier comparison of data. The functionality to view data with the Time Series Viewer application is also due to the presence of the REST API in the Gauge Viewer app, which is read by the Time Series Viewer app to retrieve and display the data.

3.2.5 Register a Referenced Time Series Resource in HydroShare

The ability to register a Referenced Time Series Resource in HydroShare allows users to create a resource that is accessible directly from HydroShare. This allows for simplified sharing of data, the ability to save data for later reference, and the ability to view the data with multiple other applications which are available through HydroShare. A Referenced Time Series Resource in HydroShare contains a URL and metadata which references a single time series for a single variable. Because of this, the ability to upload either flow or stage data from an AHPS forecast location, or instantaneous or daily mean discharge from a USGS gauge is available. For AHPS locations all available data are referenced by default, and no option to change that is given to a user. For USGS gauge locations the Referenced Time Series can be made to take a ‘static’ image of only the currently displayed data, of data for a certain time period preceding the present, or for all available data. Many sites have data available as early as the early 1900’s, or only have data available for a set number of years during the last century, and the ability to reference all of it should be of benefit to users.

When a Reference Time Series is created, information that is required to make the resource public and accessible by others, including the title, abstract, and keywords, are generically populated, and the user is able to edit them as desired. An example of how USGS data can be registered as a HydroShare resource can be seen in Figure 3.2.5-1.

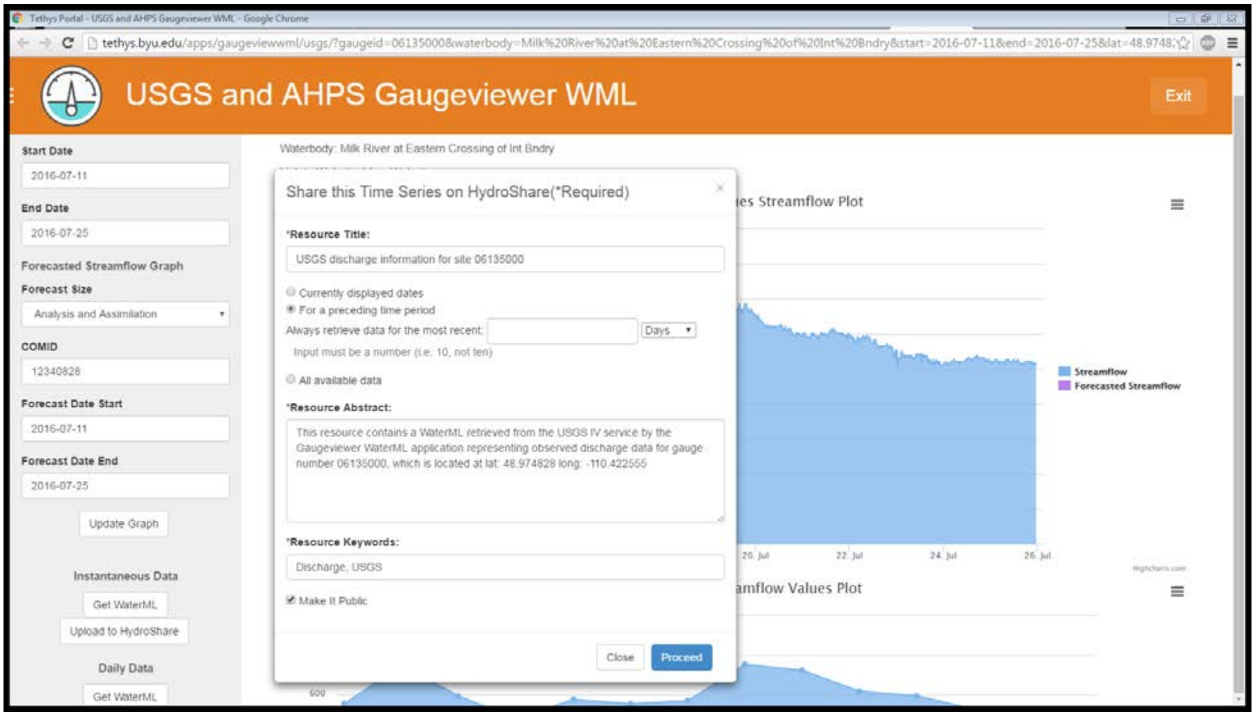

Figure 3.2.5-1: Registering a Resource in HydroShare

3.2.6 Compare to National Water Model Forecast Data Based on COMID

Both USGS and AHPS streamflows can be compared to several different forecast products from the National Water Model (NWM). These forecasts are generated on a regular basis, and comparison of NWM forecasts to actual discharge conditions and regional water center forecasts will allow water center managers to further refine forecasting abilities and improve accuracy of future forecasts. The benefit provided from this application is that it is relatively easy to do. The COMID, a uniquely assigned value for each stream segment in the National Hydrography Dataset (NHD), of the nearest stream segment from the NHD is automatically generated by the application and initialized on page load for the user. It has been seen in a few instances that when a gauge is near a junction of multiple segments the precision of the location of the gauge may not populate the proper COMID, however, users can (and should) manually verify the proper COMID for any gauge of interest, and input a different COMID if appropriate. This ability will also allow users to compare flows with forecasts from other stream segments, such as forecasts upstream or downstream of the gauge location. An example of how a medium range forecast for a given COMID can be compared with information at a USGS gauge is seen in Figure 3.2.6.1.

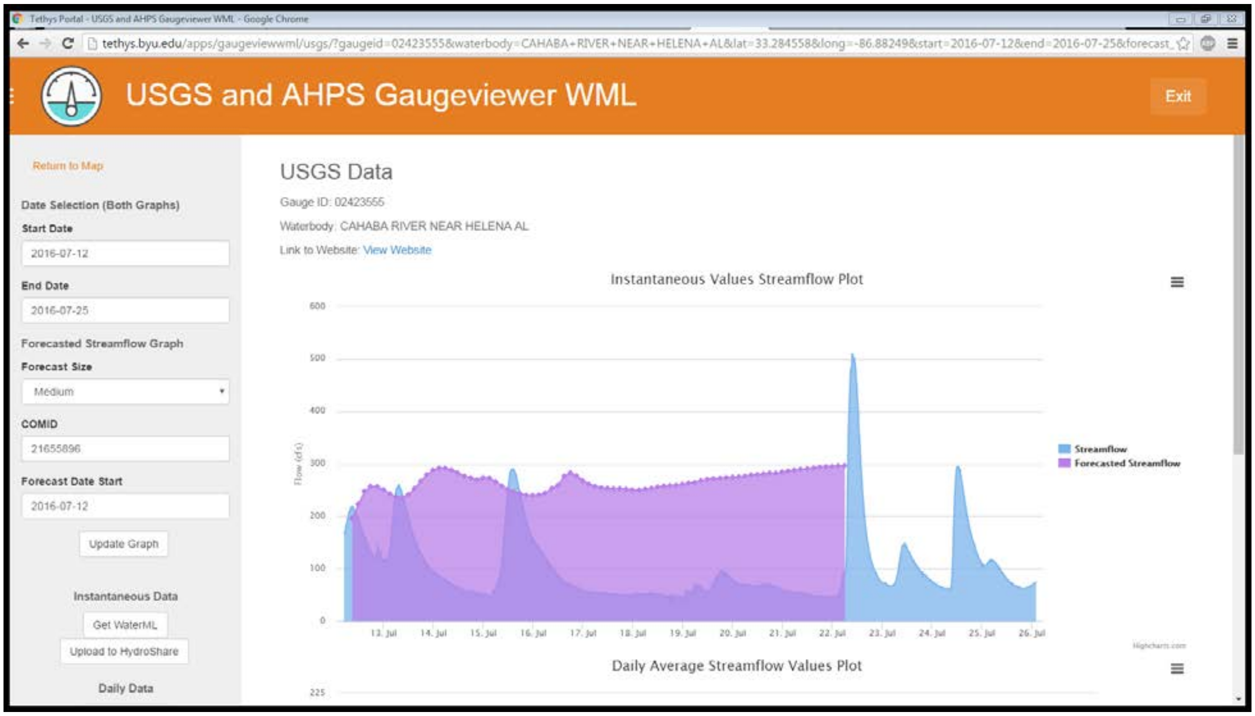

Figure 3.2.6-1: Comparison of Gauge and Forecast Data

4 CONCLUSIONS

Cyberinfrastructure in water resources is a relatively new field, undergoing rapid growth and development. There is a lack of tools which utilize and combine web services to provide a web service with greater functionality to end users. There is a need for specific application examples of how water resource web services can be synthesized to create an improved web service.

The Gauge Viewer WaterML application demonstrates the ability to synthesize existing web services and produce a web service which makes data even more readily found and used. The Gauge Viewer WaterML app specifically provides a way to discover data from two existing web services, the USGS NWIS values service and the NOAA NWS AHPS forecast service, in such a way that additional web services could also be added. The ability to compare NWM forecasts to streamflow data from the USGS or AHPS forecast data is presented for the first time by this application. The ability to compare NWM forecasts to USGS data allows for easy comparison of forecasts to assist in refining forecasting capabilities.

The Gauge Viewer WaterML provides a REST API which returns requested data in the WaterML format. The REST API provides data access to any third party application or script, including the ability to publish referenced time series resources on HydroShare, allowing for social interactions with the data, further encouraging data usage.

This application demonstrates that the provided goals can be met. This application demonstrates the abilities of a REST API, which allows for gauge data from the app to be retrieved from other applications or programs without requiring a user interface, through its use in several different functional components of the application.

This application will serve as a guide and template for functionality of future applications which desire to combine web services as a web service. The Gauge Viewer WaterML REST API also serves as an example for how Tethys applications can be designed to access information through third party applications. The inclusion of a WaterML creator will be valuable for future applications which desire to provide data in the WaterML format. Due to rapid advancements in technology and cyberinfrastructure it is expected that this application will be outdated relatively soon, but the abilities and functionality of the app serve as an example for others who desire to build applications with similar functionality.

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