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# Alaska Pacific River Forecast Center Operations

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The National Weather Service (NWS) provides weather, hydrologic, and climate forecasts and warnings for the United States, its territories, adjacent waters and ocean areas, for the protection of life and property and the enhancement of the national economy. In support of this NWS mission, the Alaska-Pacific River Forecast Center (APRFC) produces timely and accurate water forecasts and information using the best available scientific principles to integrate and model water, weather, and climate information. An overview of APRFC operations will be presented covering several of the unique flood forecasting challenges within our area and provide information on observing programs developed to improve forecast accuracy in our challenging northern environment. Several of these operational observing programs are unique within the NWS to our operations, and consist of a team of citizen observers that provide year round information throughout the State of Alaska, a small low cost river stage gage developed to supplement a sparse network of stream gaging stations, and a long term program known as River Watch. River Watch is a joint operation with the Alaska Division of Homeland Security and Emergency Management to provide flooding preparedness information and monitor river breakup conditions in real time through daily aerial reconnaissance throughout the State of Alaska. Small multi-agency teams follow the breakup front as it advances downstream past many small Alaska communities primarily on the Yukon and Kuskokwim Rivers. These teams provide air to ground river reports in real time to each community as they closely monitor the river for changing conditions and the formation of ice jams.

## 1. Introduction

The National Weather Service (NWS) provides weather, hydrologic, and climate forecasts and warnings for the United States, its territories, adjacent waters and ocean areas, for the protection of life and property and the enhancement of the national economy. NWS data and products form a national information database and infrastructure which can be used by other governmental agencies, the private sector, the public, and the global community.

The NWS currently has 122 Weather Forecast Offices (WFOs), 13 River Forecast Centers (RFCs), and 5 National Centers for Environmental Prediction (NCEP). Six regional offices and a national headquarters office in Silver Spring, Maryland administratively and technically support these field offices.

NWS River Forecast Centers have four basic functions:

1. Continuous hydrometeorological data assimilation, river basin modeling, and hydrologic forecast preparation.
2. Technical support and interaction with supported and supporting NWS offices.
3. Technical support and interaction with non-NWS partners and customers.
4. Applied research, development, and technological implementation to facilitate and support the above functions.

The Alaska Pacific River Forecast Center is located in Anchorage and provides hydrologic services for the three Alaska Region WFOs located in Anchorage, Fairbanks and Juneau. This paper provides an overview of the APRFC and some of the programs and observing systems we have developed and are working on to meet our unique challenges in Alaska. The eleven-person staff of the APRFC consists of one Hydrologist-in-Charge, one Development and Operations Hydrologist, one Service Coordination Hydrologist, three hydrologists, three hydrometeorologists, one technician and an Information Technology Officer.

APRFC core customers include:

- Weather Forecast Offices in Alaska and Hawaii (4)
- State of Alaska Department of Homeland Security
- Local Emergency Managers
- Federal Agencies
- Alaska Department of Transportation
- Recreational River Users
- General Public

APRFC Vision Statement: " Keeping a Watch Over Alaska's Waterways "

## 2. History and Annual Operations Cycle

As early as 1948 the US Weather Bureau regional office in Anchorage began planning for a rain gage network, specifically intended for hydrologic purposes. At the same time, the Bureau of Reclamation requested that the Alaska Region Office install and operate a precipitation storage gage on the Eklutna River Basin in South-central Alaska. The Eklutna River was home to one of Alaska’s earliest commercial hydroelectric plants.

The Weather Bureau hydrology program in Alaska got its formal start as a result of a disaster survey team investigating the great 1964 Spring breakup flood in the Interior of Alaska. Based on the team's recommendation, in 1965 two staff were hired to start the hydrology program in the Alaska Region. The hydrology program staff quickly realized that the lack of observed river data would prevent accurate forecasting and began to install additional river gages throughout the state. Many of these gages were 'slope gages', which were surveyed on riverbanks, and are still in use today. Then, in August 1967, the record breaking Chena-Tanana flood occurred. The Weather Bureau was subject to some criticism due to inadequate service during this flood and the Regional Hydrologist ended up shouldering much of the blame for the quality of the warnings issued for the Fairbanks area. In 1971 Congressional funding was appropriated to fund two new River Forecast Centers, the Lower Mississippi River Forecast Center in New Orleans and the Alaska River Forecast Center (AKRFC). The AKRFC was established in the summer of 1971. In 1997, the AKRFC accepted technical responsibility for the NWS Pacific Region's hydrology program and was renamed the Alaska-Pacific River Forecast Center. The NWS Pacific Region is the only region that does include a river forecast center. The APRFC provides technical hydrologic support for the Pacific Region, however, there are no official river forecasts points within the Pacific Region.

The APRFC annual operations cycle shown in Figure 1 is dominated by several distinct seasons. The summer season is primarily driven by open water conditions with river forecasts developed using the lumped Sacramento Soil Moisture Accounting (Sac-SMA) hydrologic model (Burnash et al., 1973).

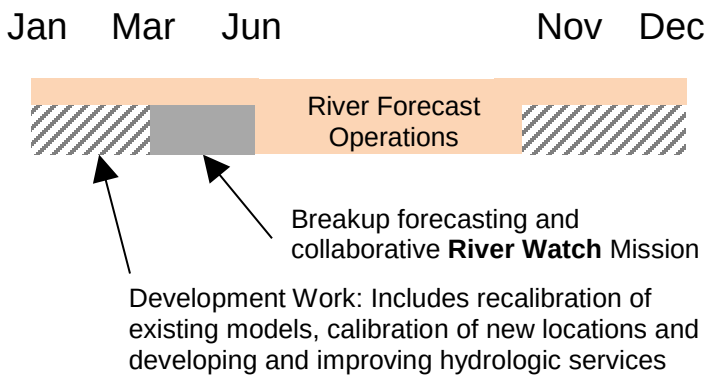


Figure 1. APRFC Annual Cycle of Operations.

Sac-SMA is a conceptual model that attempts to represent soil moisture characteristics to effectively simulate runoff that may become stream flow in a channel. These river forecasts are provided in both text and graphical format (Figure 2) with both observed and forecast data presented in an easy to use format.

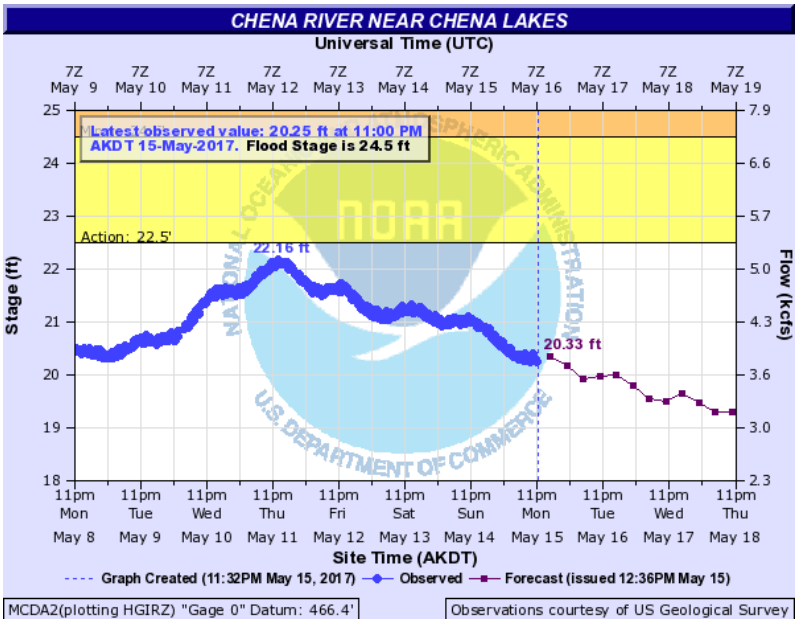


Figure 2. Example APRFC open water season hydrograph. The primary plotted variable is river stage on the left axis with discharge included on the right axis. Flood stages are highlighted in the plot to provide users with information related to flood impacts.

Daily river forecasts are not produced during the winter months or during spring breakup. However, APRFC staff continue to monitor river conditions throughout the state, as the possibility of flood producing weather can occur in southern Alaska and glacier dammed lake outburst flooding is possible year round.

Post and Mayo (1971) catalogued over 750 glacial dammed lakes in Alaska. Glacial dammed lakes are routinely monitored and, once an outburst is detected, downstream flow forecasts are developed using separated hydrographs from previous events. Figure 3 below illustrates an example library of glacier outburst flood hydrographs separated from the Kenai River base flow downstream of Skilak glacier dammed lake. These separated hydrographs are used as analog events to assist in generating short-term forecasts. This library of events is pre-populated in our forecasting system and can be quickly added to the rainfall runoff simulation to produce a total forecast that includes the glacial dammed lake release.

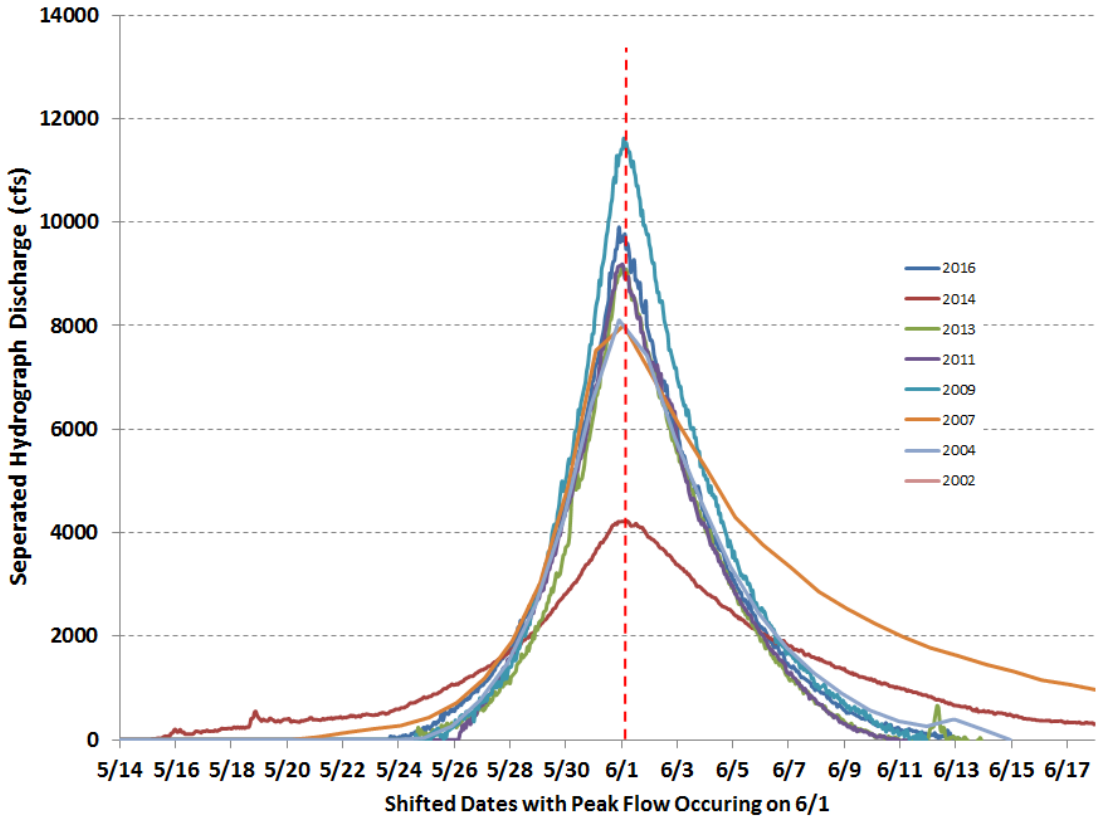

Figure 3. Example of glacial dammed lake release hydrographs. Historic event data are used as analogs for glacial dammed lake flood forecasting.

In addition to monitoring for unusual winter flooding events, model development work replaces the daily forecast schedule during the winter months. Development work is required to improve data handling systems and extend the Sac-SMA model to new watersheds. While all meteorological modeling within the NWS is centralized at NCEP centers, hydrologic model development and operations is currently performed at the regional river forecast centers. Currently the APRFC has hydrologic models for less than ½ of Alaska.

A program known as 'River Watch' dominates APRFC operations from late March through late May. This program was developed in the 1970's to provide timely decision support information during the dynamic transition from fully ice-covered rivers to completely open water.

## 3. Spring Breakup Season and River Watch

The NWS is responsible for monitoring and forecasting river ice breakup conditions throughout Alaska to assess flood threats and navigational hazards.

Each spring, prior to breakup, the APRFC provides breakup outlook briefings for interested stakeholders and the public. These briefings are one of the primary tools used to provide qualitative outlook information related to breakup timing and the likelihood of flooding at locations throughout the State. Breakup timing is generally based on a temperature index model

that utilizes historical average temperature with additional information included from longer range temperature outlooks. The qualitative assessment of the likelihood of flooding is primarily based on subjective analysis of winter temperatures, statewide snowpack conditions and measured ice thicknesses.

Once breakup commences, ground observations, aerial reconnaissance, and remote sensing are all sources used to assess ice conditions. This program of collectively gathering and assessing river ice conditions through out Alaska is referred to as 'River Watch'.

APRFC has relied for many years on observations from Alaska village residents describing the river ice condition in front of the village. Supplemental aerial observations from aircraft flying at low to mid-level altitudes have significantly enhanced the information on ice conditions. Since ice conditions can vary significantly along a river and can change rapidly during the breakup process, numerous observations are needed statewide to assess the status of breakup.

Primary data sources for River Watch include:

- Direct aerial reconnaissance

  APRFC works collaboratively with the State of Alaska to perform daily reconnaissance flights along the Yukon and Kuskokwim Rivers for approximately two to four weeks during the breakup season. River ice information is relayed directly to communities from the air where communications allow, with up to date conditions and hazards conveyed in near real time.

- Pilot reports

  A system has been established in Alaska where pilots can submit a pilot report (PIREP) to the nearest flight service station. A PIREP is a report of actual weather conditions encountered by pilots. During the breakup season, pilots can also submit river ice PIREPS that follow an established set of standard remarks. These reports are automatically relayed to the APRFC. The NWS in Alaska has established a training program to educate and encourage pilots to submit river ice PIREPS. The FAA Flight Service Stations are quite supportive of this program, with NWS staff providing training presentations to FSS staff to assist the implementation. More details of this pilot reporting program along with a set of standard PIREP remarks can be found online: http://www.weather.gov/aprfc/riverWatchProgram

- Local observer reports

  Observers in communities across the state report local river conditions via telephone and, more recently, text messages. Approximately thirty-five communities lie along the Yukon and Kuskokwim Rivers with many additional communities along other rivers.

- River gage information

  River gage data can provide valuable stage information during breakup. However, should a gage have an equipment failure due to ice the gage is generally left as-is until the river is completely ice-free. Gage visits often require air transport and, in some cases, several days to perform a site visit.

- Satellite Data

APRFC staff regularly review MODIS and VIIRS imagery for ice conditions and more recently has been operationally utilizing a new river ice product derived from the SNPP/VIIRS satellite (Li et al., 2015) shown in Figure 4. SNPP/VIIRS data show special advantages in flood detection including: multiple observations per day in high latitudes and are well suited to detect snow-melt and ice-jam floods due to less contamination from cloud cover than floods caused by intensive rainfall. Satellite born Synthetic Aperture Radar (SAR) is also used when available.

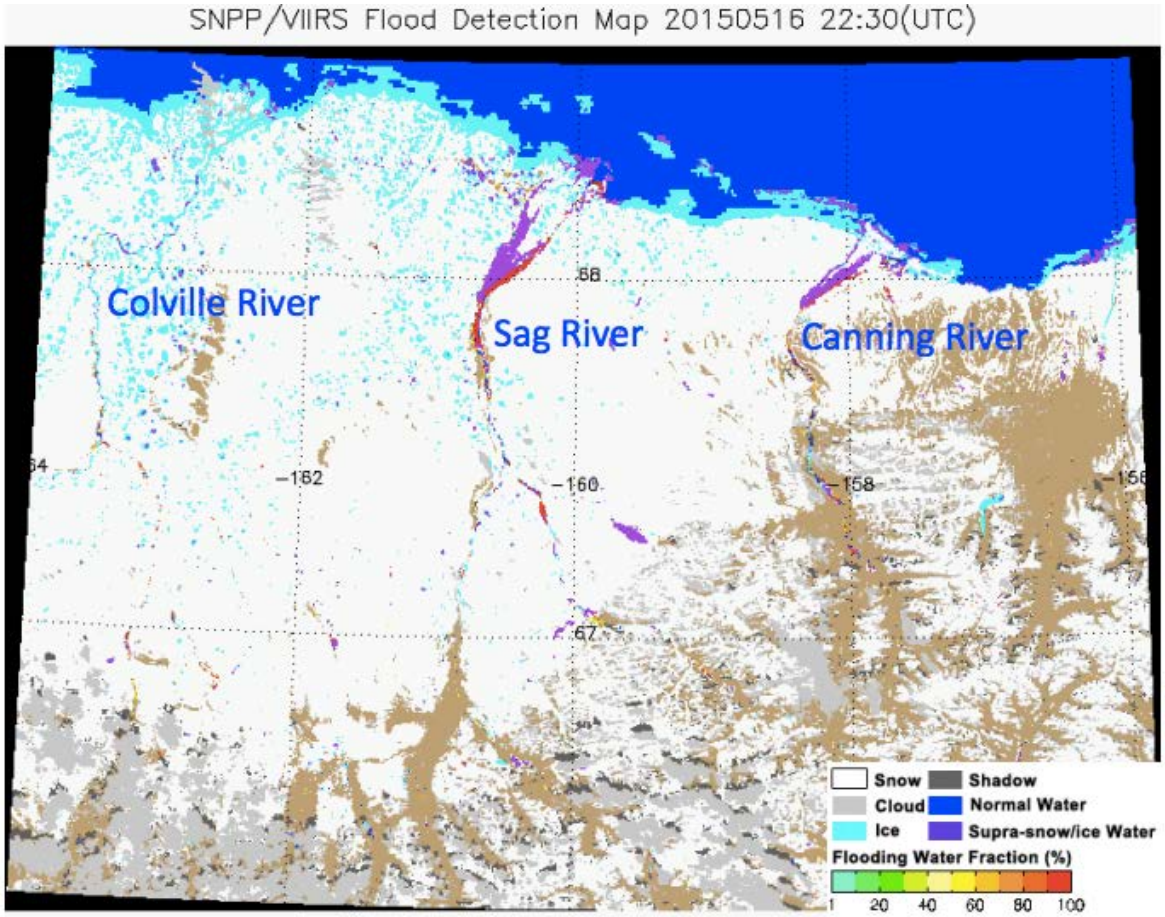


Figure 4. Example SNPP/VIRRS JPSS River Ice and Flood Product from May 16th 2015. This image shows an area of widespread flooding and water over snow and ice along the Sagavanirktok River on the North Slope of Alaska.

River breakup information is analyzed daily, with results provided as a text product as well as an easy to understand graphical product. This graphical product is updated periodically throughout the day as conditions change, and contains river ice condition information and any warning, watch or advisory products issued. An example breakup map from the 2017 season is shown in Figure 5.

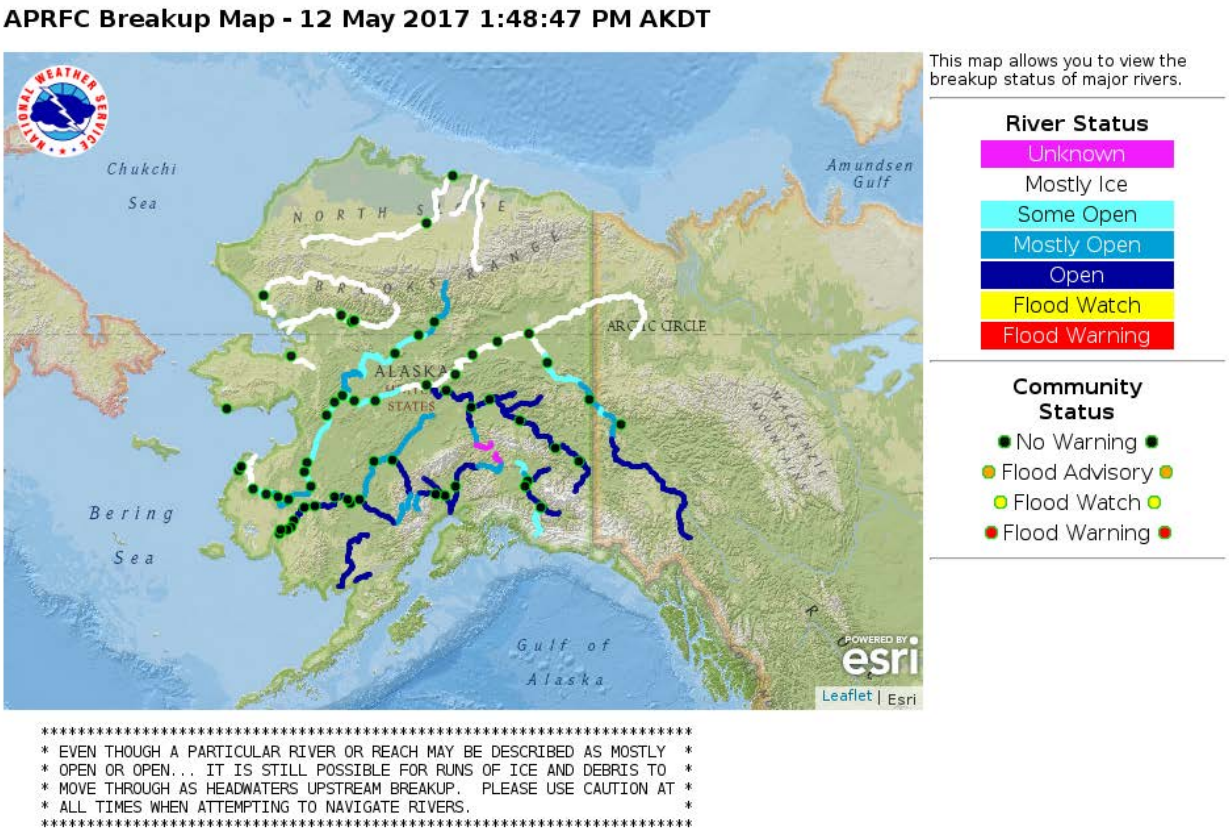


Figure 5. Alaska River Breakup Map with color-coded river reaches representing the estimated local ice conditions.

## 4. Low Cost River Stage Gages

Real-time river data is critical to issuing forecasts and flood warnings to the public and NWS partners. But real-time data coverage and availability has always been a challenge in Alaska, where most locations cannot be accessed by road. The United States Geologic Survey (USGS) owns and operates the majority of Alaska's river gage network. However, this network does not provide the density of observations required to adequately monitor and provide flow forecasts at locations with direct flood impacts to infrastructure. NWS hydrologists recognized that the USGS stream gage network needs to be supplemented with additional river gages in Alaska.

The NWS Alaska-Pacific River Forecast Center has developed and tested a compact, low cost, ultrasonic river stage gage with global satellite telemetry. These gages started out as a concept for a rapidly deployable flood monitoring device that was small, self-contained, and with global telemetry. The gage is a unique combination of off-the-shelf and custom components in a small, low cost package that is easy to mount and maintain. The small package (3 inches x 5 inches x 7 inches) is completely self-contained and includes a solar charging power supply. Over the past three years approximately low cost gages have been deployed in Alaska.

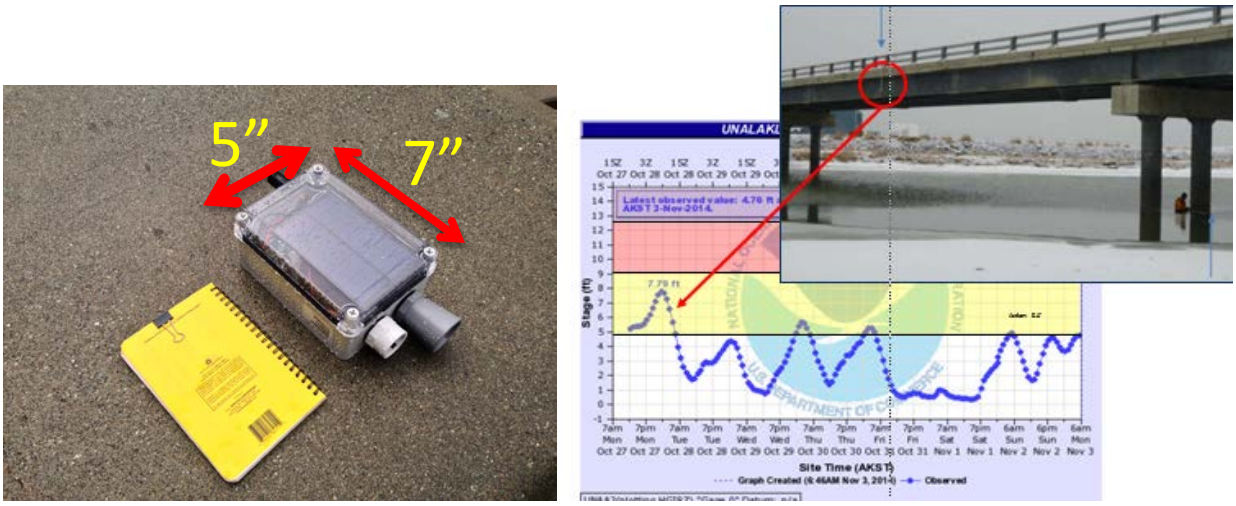

Figure 6. Photograph of a the APRFC low cost telemetered stage gage (left) with a photograph of a typical installation on a tidally affected bridge.

This new low cost instrument has improved our real-time hydrometeorologic data network across Alaska, but it does have limitations:

- Acoustics sensors are noisier and less accurate than a pressure transducer or radar sensor when measuring water levels.
- Range limited to 10 meters.
- Data does not meet US Geological Survey river stage measurement standards (estimated accuracy for river stage is approximately ± 5 cm depending upon the measured distance)
- Gages are fabricated in-house in small numbers.
- Operation over ice is affected by snow with outages during low density snow events.

Future work on this low cost gage includes continued testing for durability and software stability, improvements to the acoustic sensor accuracy (in-progress), improvements to the air temperature measurement (in-progress) and a re-designed custom circuit board for streamlined production.

## 5. Conclusions

This short paper provides an overview of the Alaska Pacific River Forecast Center and some of the unique challenges and programs the RFC has developed or collaborated on to improve service to our core partners and the general public. The office continues to develop and use new technology to meet our core mission and provide decision support services to our customers. In the future we expect to expand our use of remote sensing to support our River Watch operations. The satellite derived river ice product has been extremely valuable to our operations and we expect to expand our use of satellite data and derived products. We are also optimistic that unmanned aerial systems could provide additional near real time river observation data in the future.

## References

Burnash, R. J., R. L. Ferral, and R. A. McGuire, 1973. A generalized streamflow simulation system conceptual modeling for digital computers, U.S. Department of Commerce National Weather Service and State of California Department of Water Resources.

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