

CAKN Stream Monitoring Program

2016 Annual Report



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On the cover: Aerial view of the Charley River, YUCH. The CAKN Stream Monitoring Program sampled 2 streams in the Charley River basin in 2016.

Summary

During the 2016 field season, the Central Alaska Network (CAKN) Stream Monitoring Program made 75 sampling visits to 39 unique stream sites across the network, with each site being sampled between one and five times from early May through late September (Figure 1, Table 2). High water or lack of water prevented sampling during a number of additional site visits. Field work was scaled back somewhat in comparison to previous years to allow more focus on management and analysis of data collected in previous years. The data collected included instantaneous water chemistry, stream flow, water chemistry samples, macroinvertebrates, stable isotope samples, habitat data and environmental DNA (eDNA) samples. We successfully used eDNA to detect the presence of multiple fish species at several sites in the network. Continuous year-round temperature monitoring at 22 sites across the network is ongoing, and is now in its 8th year at some sites. All deployed temperature dataloggers were replaced during 2016, and duplicate dataloggers were added at 10 sites. A time-lapse camera installed in 2012 at Jack Creek in WRST to monitor flow, turbidity and the timing of freeze-up and break-up was stolen sometime during the summer. Four site visits were made to the stream gage on the Nabesna River just outside of WRST to perform station maintenance and collect discharge and water chemistry data. During the fourth site visit in October, a new permanent well/sensor was installed to replace the existing permanent well/sensor, which had developed an unacceptable lag time. This gage has been operated as a cooperative effort between CAKN, The US Fish and Wildlife Service and the NOAA River Forecast Center since 2012. 10 years of continuous discharge and temperature data have now been collected. A final version of the CAKN Stream Monitoring Program 2011 Annual Report is available as a Natural Resources Technical Report in IRMA at the Stream Monitoring Project page – (<https://irma.nps.gov/DataStore/Reference/Profile/2215908> - Annual Reports for 2006-2015 are also available there). Beginning in 2012, we stopped issuing extensive annual reports, and replaced them with shorter these Field Season Reports. More extensive synthesis reports including analyses of most data collected by the program to date will be published over the next several years. The Stream Monitoring Protocol, including a Protocol Narrative and 18 Standard Operating Procedures, has been approved and is in publication. The Standard Operating procedures have already been published and are at the Stream Monitoring Project page; the Protocol Narrative will be published shortly as a Natural Resource Report.

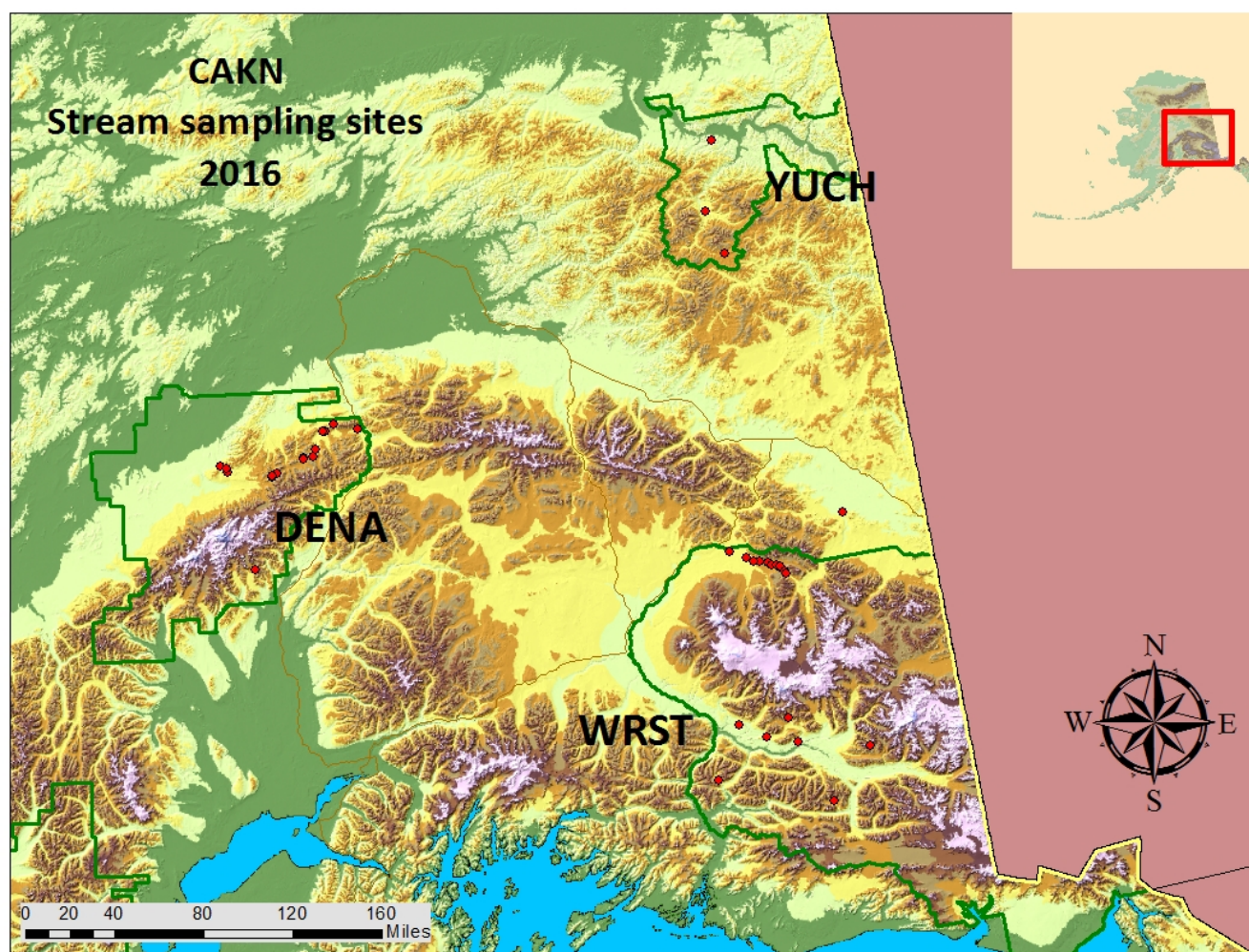


Figure 1. Locations of sites sampled by the stream monitoring program during 2016. Individual sites were sampled one to five times from May through September.

Continuous temperature data collection

Beginning in 2008, continuously recording temperature loggers have been deployed in streams along the Denali Park Road, and along the Nabesna and McCarthy Roads in WRST. At present, there are temperature loggers deployed at 22 sites in DENA and WRST (Table 1). A datalogger that records both conductivity and temperature was deployed in Coal Creek in YUCH in 2015. For the first two years, the dataloggers were deployed in late spring and removed in the fall, but they are now left in place throughout the year. Currently the dataloggers are changed out approximately every 2 years, although because temperature data are recorded hourly, there is enough memory to leave them deployed for 3 years in cases where they cannot be retrieved after 2 years. In 2016, all deployed recorders were changed out, as they were nearing the end of their battery life, and duplicate units were deployed at 10 sites. Duplicate loggers will be added to the other 12 sites in 2017. As funding allows, all temperature loggers will eventually be replaced by loggers that record conductivity and temperature. Continuous temperature data will allow us to detect changes in the temperature regimes of park streams over time. Exploratory analysis of the data collected to date has revealed a variety of temperature regimes among network streams, and substantial variation among years at some sites (Figure 2), but as

Table 1. Locations of currently-deployed continuous temperature dataloggers in CAKN parks. The datalogger at Coal Creek also records conductivity.

Site Code	Site Name	Park Unit	Notes
DENA-001	Rock Creek	DENA	Since 2009
DENA-008	Little Stony Creek	DENA	Since 2008
DENA-017	Tattler Creek	DENA	Since 2009
DENA-021	Hogan Creek	DENA	Since 2008
DENA-029	Lake Creek	DENA	Since 2008
DENA-033	Gorge Creek spring	DENA	Since 2009
DENA-034	Wonder Lake inflow	DENA	Since 2012
DENA-GRTS-010	Moose Creek	DENA	Since 2008
DENA-GRTS-014	E.F. Toklat tributary	DENA	Since 2009
DENA-GRTS-060	Savage River	DENA	Since 2008
DENA-GRTS-084	Igloo Creek	DENA	Since 2008
DENA-GRTS-104	Sanctuary River	DENA	Since 2008
WRST-004	Chalk Creek	WRST	Since 2008
WRST-006	Rock Creek	WRST	Since 2008
WRST-013	Gilahina River	WRST	Since 2008
WRST-015	Little Jack Creek	WRST	Since 2008
WRST-036	Rufus Creek	WRST	Since 2009
WRST-039	Caribou Creek	WRST	Since 2008
WRST-051	Long Lake Creek	WRST	Since 2008
WRST-060	Paco Creek	WRST	Since 2011, @ Mile 27 Nabesna Road
WRST-GRTS-032	Crystal Creek	WRST	Since 2010
WRST-GRTS-130	Jack Creek	WRST	Since 2008
YUCH-GRTS-003	Coal Creek	YUCH	Since 2015

of yet have not revealed any temporal trends. It is likely that at least 10 years of data will need to be collected before we have sufficient statistical power to detect trends. As Figure 2 shows, there is a great deal of variability in the temperature regimes we have observed. Three representative temperature regimes are displayed. Spring-fed creeks (Figure 2 Top) exhibit very little variation in temperature across years, with the temperature essentially remaining between 2 and 4 degrees Celsius year round. Groundwater-dominated streams like Rufus Creek (Figure 2 Middle) exhibit increased, though still modest, variability through the year. Rufus Creek varies from ~3 to 8 degrees Celsius in the summer, and between 0 and 2 degrees in the winter. Streams like this often do not freeze in the winter, or freeze only partly. Runoff-dominated streams like the Gilahina River (Figure 2 Bottom) generally show more variability in temperature, both through the year and on a daily basis in the summer. The Gilahina River varies between 5 and 13 degrees Celsius during the summer, and stays at or near 0 degrees throughout the winter. Streams like this warm up faster in the spring, cool down faster in the fall, and usually freeze over completely during the winter.

Field data collection

Collection of field data during repeated visits to selected sites across the network is a critical component of the CAKN Stream Monitoring Program. Three types of sites are sampled – sentinel sites, GRTS sites, and judgment sites. Sentinel sites, all of which are currently located along the Denali park

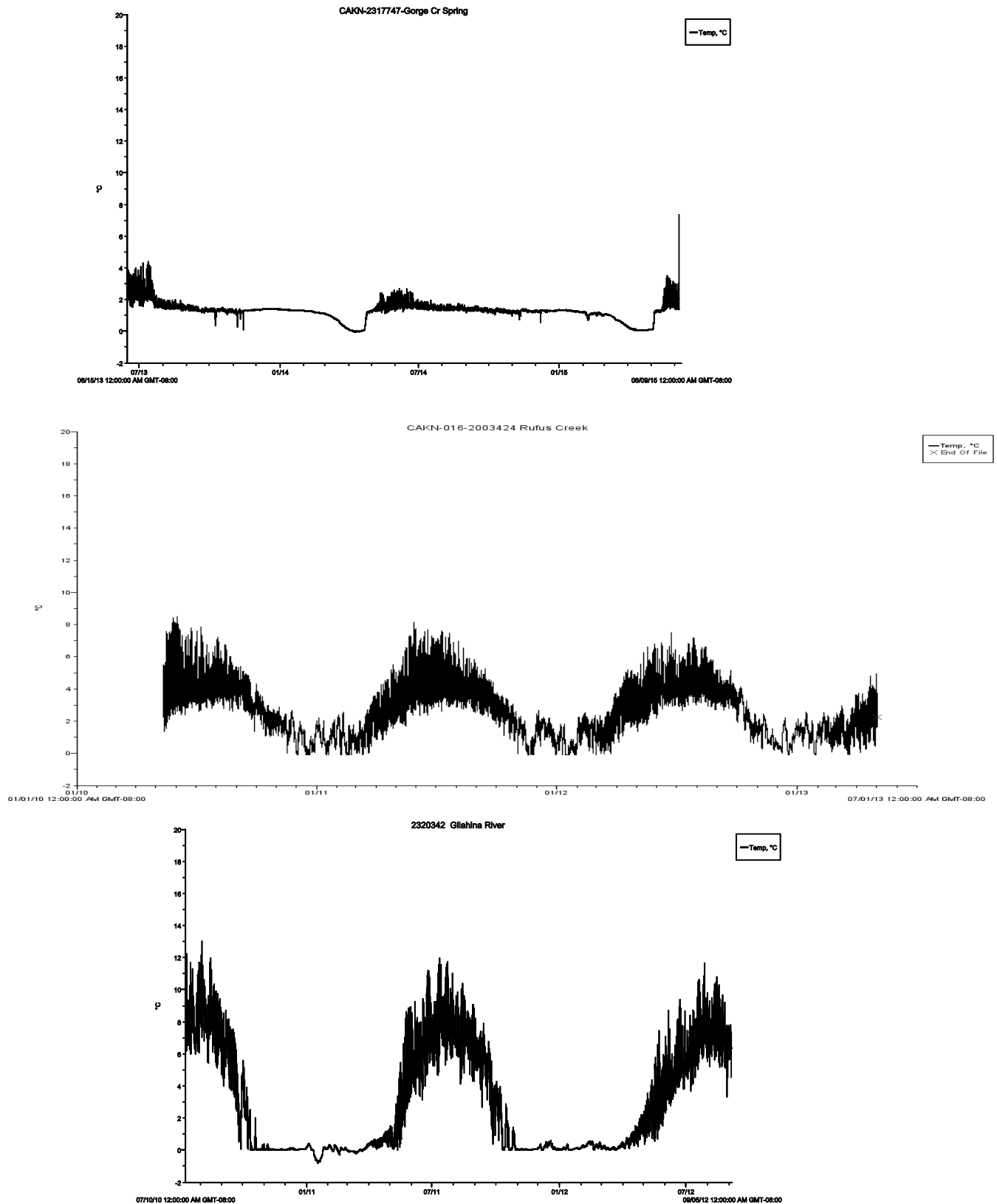


Figure 2. Examples of multi-year temperature data collected by the CAKN Stream Monitoring Program. Top: a spring-fed creek near Eielson Visitor Center in DENA. Middle: Rufus Creek in WRST. Bottom: Gilahina River in WRST. Temperature scales (vertical axis) are the same.

road and the Nabesna and McCarthy roads in WRST, are sampled approximately annually to maximize our ability to detect changes. Some of these sites are also sampled multiple times per year as a way to help quantify seasonal variability in ecological metrics. Many of the sentinel sites in DENA were originally part of the Long Term Ecological Monitoring (LTEM) program. Although at this point there are no sentinel sites in YUCH, because there are no road-accessible areas, we plan to identify at least

Table 2. List of sites sampled by the CAKN Stream Monitoring Program in 2016

Site Code	Site Name	Park Unit	Notes
DENA-001	Rock Creek	DENA	Sampled annually, first LTEM site
DENA-004	Travertine stream	DENA	Unusual water chemistry
DENA-008	Little Stony Creek	DENA	Sampled annually, LTEM site
DENA-009	Little Stony Creek trib	DENA	Judgment site
DENA-017	Tattler Creek	DENA	Sampled annually, LTEM site
DENA-021	Hogan Creek	DENA	Sampled annually, LTEM site
DENA-029	Lake Creek	DENA	Sampled most years
DENA-034	Wonder Lake inflow	DENA	Sampled annually
DENA-036	Friday Creek	DENA	Legacy mining impacts
DENA-051	Ruth Glacier trib	DENA	Clearwater stream blocked by glacier
DENA-GRTS-010	Moose Creek	DENA	Sampled annually, GRTS site, LTEM site**
DENA-GRTS-014	E.F. Toklat tributary	DENA	Sampled annually, GRTS/LTEM site, [Coal Cr.]
DENA-GRTS-027	E.F. Toklat River	DENA	Sampled annually, GRTS site, LTEM site**
DENA-GRTS-060	Savage River	DENA	GRTS site, sampled annually
DENA-GRTS-084	Igloo Creek	DENA	Sampled annually, GRTS/LTEM site
DENA-GRTS-104	Sanctuary River	DENA	Sampled annually, GRTS/LTEM site
NABA2	Nabesna River	Tetlin NWR	Site of the cooperative gaging station
WRST-004	Chalk Creek	WRST	Sampled annually
WRST-006	Rock Creek	WRST	Sampled annually
WRST-011	Rock Creek tributary	WRST	Sampled annually
WRST-013	Gilahina River	WRST	Sampled annually
WRST-015	Little Jack Creek	WRST	Sampled annually
WRST-036	Rufus Creek	WRST	Sampled most years
WRST-039	Caribou Creek @culvert	WRST	Sampled periodically
WRST-051	Long Lake Creek	WRST	Sampled periodically
WRST-060	Paco Creek	WRST	Sampled annually, at Nabesna Road mile 27
WRST-069	Trail Creek	WRST	Sampled annually
WRST-070	Lost Creek	WRST	Sampled annually
WRST-071	Boyden Creek	WRST	Sampled annually
WRST-081	Falls Creek trib	WRST	Judgment site
WRST-087	Upper Young Creek	WRST	Judgment site
WRST-091	Lakina trib 2	WRST	Judgment site
WRST-095	Tana Knob creek 2	WRST	Judgment site
WRST-GRTS-021	Caribou Creek	WRST	GRTS site, sampled most years
WRST-GRTS-030	Strelina Creek	WRST	GRTS site, sampled most years
WRST-GRTS-130	Jack Creek	WRST	GRTS site, sampled annually
YUCH-010	Copper Creek	YUCH	Judgment site
YUCH-GRTS-017	Three Fingers stream	YUCH	GRTS site
YUCH-GRTS-035	Coal Creek at airstrip	YUCH	GRTS site, sampled most years

"GRTS sites" are sites that were selected using an algorithm that generates a probabilistic, spatially-balanced list of potential sampling locations to maximize inference to conditions at unsampled sites.

one in the near future. GRTS sites are selected using a probabilistic algorithm (known as “Generalized Random Tessellation Stratified”, or “GRTS”). Sampling based on a probabilistic survey design allows us to use data collected at these sites to infer conditions at sites that have not been sampled. Although some of these GRTS sites are also sentinel sites (due to a coincident location with an existing sentinel site), most are in the backcountry and will be sampled approximately once every 10 years due to the high cost of accessing them. Judgment sites are selected on an *ad hoc* basis, and for a variety of reasons. For example, the so-called “Travertine stream”, located along the DENA park road near Stony Creek, has been sampled occasionally due to its unusual water chemistry. Lake Creek was selected to make sure that a lake outlet stream was included in the set of DENA sentinel sites, since their biogeochemistry and ecology are often quite different from other stream types. Similarly, in 2016 we sampled a tributary to the Ruth Glacier in DENA because it was a small clearwater stream that is disconnected from downstream habitats by the glacier. Streams like this are common in both DENA and WRST, and due to their isolation may harbor unique flora and fauna. They may also be sensitive to climate-induced changes in glacial extent. In all of these cases I am attempting to broaden the ecological scope of streams that have been sampled. This is a critical aspect of the overall sampling approach of the Stream Monitoring Program, because probabilistic sampling schemes do not necessarily capture the full range of ecological conditions across a landscape, something that is important for ecological modeling.

Overall in 2016, 75 sampling visits were made to 39 unique sites in the network (Figure 1, Table 2). Data collected during these sampling visits included instantaneous water chemistry (temperature, conductivity, dissolved oxygen, and pH), habitat characteristics and stream flow, as well as water chemistry samples, stable isotope samples, benthic invertebrate samples and environmental DNA (eDNA) samples. Not all data were collected during every sampling visit, but at a minimum instantaneous water chemistry parameter values were recorded. In most cases, a qualitative assessment

Table 3. Water chemistry parameters collected by the CAKN Stream Program and the rationale for collecting them.

Water Chemistry Parameter	Rationale for Sampling
Instantaneous temperature*	Required WRD core parameter
Continuous temperature	Affects habitat suitability, life history for aquatic organisms
Dissolved oxygen (DO)*	Required WRD core parameter, primary productivity and distribution of biota
pH*	Required WRD core parameter, affects habitat suitability for aquatic organisms
Specific conductivity*	Required WRD core parameter. Indicator of geology, affects distribution of biota, often correlated with mean annual temperature and presence of pollutants
Total nitrogen	Trophic state, nutrient dynamics
Total nitrate/nitrite nitrogen	Biogeochemistry, nutrient dynamics
Ammonia-nitrogen	Biogeochemistry, nutrient limitation
Dissolved organic nitrogen	Biogeochemistry, nutrient dynamics
Total phosphorus	Trophic state, biogeochemistry, nutrient dynamics
Orthophosphate	Measure of biologically available phosphorus, trophic state, biogeochemistry, nutrient dynamics
Apparent color	Light availability, carbon metabolism
Silica	Required for diatom growth
Alkalinity	Buffering capacity of water – changes have been related to permafrost degradation
Calcium and magnesium	Measure of water hardness
Base cations/anions	Measure of weathering rates and indication of retrogressive thaw slumps
Dissolved organic carbon (DOC)	Measure of organic matter contributions from terrestrial ecosystems, indication of permafrost degradation, correlated with bioavailable Hg

*represent core water quality parameters required by the NPS Water Resources Division (WRD)

of stream flow, rather than an actual flow measurement, was recorded, due to time and personnel constraints.

Table 3 shows the chemical constituents and parameters that are collected by the CAKN Stream Monitoring Program, along with a brief description what each can tell us about stream ecosystems. Several of these constituents are important determinants of water quality; therefore, any observed exceedances of Alaska state water quality standards will be reported to the Alaska Department of Environmental Conservation. Through 2016, instantaneous water chemistry data have been collected during 717 sites visits, and 340 water chemistry samples have been collected and analyzed. Note that laboratory analyses for the 2016 water chemistry samples have not yet been completed.

Water chemistry samples are analyzed for a variety of constituents (Table 3), which provide important information about a variety of aspects of stream ecosystems. We are currently in the process of analyzing all of the instantaneous and laboratory results. There are several objectives for these analyses. First, we are using these data to look for spatial patterns in stream water chemistry, as well as to develop stream classifications that may reveal non-geographic patterns, and how those patterns may relate to other aspects of stream ecosystems, such as species distribution and diversity. Secondly, we are using data collected repeatedly at sentinel sites to search for any trends in the value of water chemistry parameters, either at individual sites, or at a regional scale. The results of these analyses will be published in the near future.

Since 2010, the CAKN Stream Monitoring has been collecting samples for analysis of stable isotopes of oxygen and hydrogen. Through 2016, we have collected and analyzed 154 stable isotope samples. Ratios for the concentration of deuterium (^2H) relative to ^1H , and for ^{18}O relative to ^{16}O in a water sample can be used together to estimate the relative contributions of different water sources (*e.g.*, glacial, snowmelt, rainfall, groundwater) to stream runoff. We expect climate warming to alter all of these source waters, and to alter their impact, relative or absolute, on the hydrology of network streams and rivers, with subsequent effects on stream and river ecosystems.

Since 2006, 293 benthic macroinvertebrate samples have been collected by the CAKN Stream Monitoring Program, resulting in the identification of 210 unique taxa. Not counting specimens collected in 2016, we have identified a large number of new state species records for Alaska (28), two new species records for North America, and at least five previously undescribed species, in the collection. Because it is often challenging to identify larval invertebrates to species, many of the taxa in the collection are genus-level identifications, suggesting the true species diversity in our collection is much higher than 210, and that many more state and continental species records, as well as other previously undescribed species are likely in the collection. To address this challenge, the program has adopted a two-pronged approach – collecting adult specimens, and using DNA barcoding. For many aquatic macroinvertebrate species, only adult specimens display sufficiently distinct morphological characteristics to allow a confident assignment of species identity. Accordingly, starting in 2013, the CAKN Stream Monitoring Program began efforts to collect adult macroinvertebrates during routine sampling visits. However, this effort has so far yielded only modest returns, due to the synchronized emergence of adults that characterizes the life histories of most aquatic insect species. Such synchrony means the presence of adults at a given location is dependent on the timing of the sampling visit. The second approach to obtain species-level information relies on DNA barcoding, which refers to the

sequencing of a standard portion (called the DNA barcode) of the mitochondrial cytochrome oxidase gene of a larval specimen, and comparing that sequence to a reference library of identified sequences. This reference library, call the Barcode of Life Database (BOLD), is maintained by the Canadian Centre for DNA Barcoding (CCDB) at the University of Guelph. Since 2012, the CAKN Stream Monitoring Program has been collaborating with the CCDB to develop a barcode library of Alaskan aquatic invertebrate species. To date, we have sequenced 300 specimens from the CAKN macroinvertebrate collection. This has resulted in the identification of a substantial number of additional species in our collection. However, the effort is complicated by the incomplete nature of the BOLD library, in that a majority of aquatic invertebrate species are not yet represented in the library. This means that a significant proportion of the DNA barcodes from the CAKN collection return “no match” from BOLD, or that the closest match occurs at a % identity well below the threshold for species separation. Ongoing efforts to expand the representation of aquatic insects in the database should alleviate this challenge in the future. A report summarizing the results of morphology-based taxonomic analysis and DNA barcoding through the 2015 samples is in draft form and will be published soon. In addition, a manuscript describing the new state and continental species records is in preparation.

New taxa added to the dataset based on 2016 collections include the genus *Deuterophlebia* (the “mountain midges”), collected at two sites in YUCH, and the stonefly species *Mesocapnia variabilis*, collected at Tattler Creek in DENA. In addition, two new potential species of the stonefly genus *Zapada*, and two new potential species of the stonefly genus *Nemoura*, have been separated based on the results of the latest round of DNA barcoding (they are separate species, but do not match any known DNA sequence), and corresponding sets of larval morphological characteristics.

Benthic invertebrate and basin descriptor data (derived from delineations of the upstream basin of each sampling location combined with data from a large number of GIS layers) have been used to construct several empirical predictive biological assessment models (RIVPACS models) for the Central Alaska Network. These models allow us to quantify the ecological condition of stream ecosystems, and hence their water quality, based on the degree to which the observed macroinvertebrate taxon composition at a site conforms to the expected composition (as predicted by the model). The precision of the latest iteration of the RIVPACS model we have developed (as quantified by the standard deviation of derived reference site scores) is comparable to other large-scale models developed in the lower 48. These constitute the first set of RIVPACS biological assessment models ever developed for Alaska.

One use of this approach is to monitor the success of stream restoration projects or other management actions at specific sites. Beginning in 2014, the CAKN stream ecologist has been cooperating with Robin Henderson, a graduate student from Washington State University, in developing a sampling program that will be used to evaluate the ongoing Eldorado Creek restoration project in DENA using this RIVPACS modeling approach. We are also in the early stages of applying this method to the detection of climate-induced changes in invertebrate assemblages at a regional scale.

Nabesna River cooperative gaging station

2016 marked the fifth field season for the collaborative operation of the Nabesna River gaging station. This is currently the only active gaging station located within or downstream of a network park unit. This station, located a few miles downstream of WRST in Tetlin National Wildlife Refuge (NWR), has been operated by the USFWS Water Resources Branch since 2007, and was scheduled to be removed in 2012. However, the CAKN Stream Monitoring Program has entered into a collaboration with the

USFWS Water Rights Branch, Tetlin NWR and the NOAA River Forecast Center to maintain the station indefinitely. Under this agreement, the CAKN Stream Monitoring Program is responsible for field data collection and station maintenance, Tetlin NWR provides staff time and logistical support for field visits, and the Water Rights Branch and NOAA are responsible for technical assistance, data management and analysis, and publication of the data. In 2012 the CAKN Stream Monitoring Program installed a new datalogger and GOES satellite transmitter to provide real-time river stage/discharge and air and water temperature data. Real-time stage/discharge and temperature data are available at the NOAA Hydrometeorological Automated Data System (HADS) website (<http://www.nws.noaa.gov/oh/hads/>). The NWSLI Identifier for the Nabesna River station is NABA2. The NESDIS Identifier is FED0E484.

In 2016, we made four visits to the gaging station. In March, an under-ice discharge measurement was made, which involved drilling 30 holes through the ice using an auger. The May early-season visit was cancelled due to low water. In July and September, discharge measurements were made using an acoustic Doppler current profiler (Figure 3), and routine station maintenance was performed. An additional visit was made in October to install a new permanent well and sensor (Figure 4). This was necessary due to the increasing lag observed in the response curve of the existing permanent

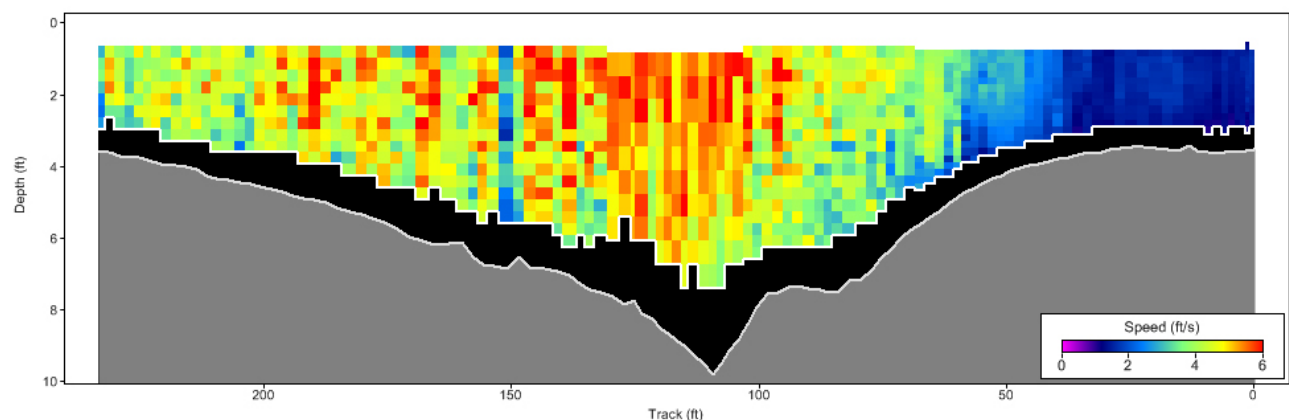


Figure 3. Example of data obtained using an Acoustic Doppler Current Profiler at the Nabesna River. The data include a bathymetric profile of the river bed, a 2-dimensional profile of water velocity, and an integrated discharge value derived from these.

well/sensor array. Such lags mean that the magnitude of high-flow peaks can be mischaracterized, and can lead to other inaccuracies in the data record as well. Discharge data from this station, the only currently operating gage within or downstream of a network park, will be used to assess hydrologic conditions upstream in WRST. As of 2016, we now have 10 years of discharge data, which is approaching the data record necessary to achieve the requisite statistical power to detect long-term changes in flow. Preliminary analyses of the data collected to date have so far revealed no such trends. Starting in 2013 we have also been collecting water chemistry and eDNA samples during each site visit.



Figure 3. Installation of a new permanent well/sensor array at Nabesna River. The well pipe is pounded through the bank at an angle (left hand photo), then a perforated well tip containing a pressure transducer is attached to the end of the pipe and buried in the sediment in the river (right hand photo). A cable carrying power and communication runs from the transducer up through the pipe to the datalogger at the transmitter station.

Assessing fish distribution using environmental DNA

The CAKN Stream Monitoring Program has been working with the USGS Molecular Ecology Lab since 2012 to develop methods to detect the presence of multiple fish species and other aquatic organisms in streams and lakes by analyzing DNA present in the environment (eDNA). Currently we use a portable peristaltic pump that allows us to filter large volumes of water in a relatively short time. Shed skin cells, feces and other biological material containing DNA are retained on the filter, which is then preserved in a detergent buffer. The DNA is then isolated and purified in the lab. We have developed a set of mitochondrial DNA markers that in combination allow us to distinguish 42 species of freshwater fish native to Alaska. We use the polymerase chain reaction (PCR) to specifically amplify these segments of DNA and then sequence them individually using next-generation sequencing technology to identify the species present in the sample. The methods were worked out using water samples from an aquarium, so that species composition was known. Importantly, we successfully detected all 6 species present in the aquarium, and there were no false positives (i.e. we did not “detect” any species that were not present).

Our results indicate that the method works well, and that we can accurately assess the fish species composition of a water body based on a water sample, although there are still challenges in accurately distinguishing among the closely related species of the genera *Cottus* and *Salvelinus*. We now have specifically designed additional primers targeted to those genera that are able to distinguish the 3 species of *Cottus* found in Alaska from one another, as well as the 3 species of *Salvelinus* found in Alaska.

The method was developed primarily using samples collected as part of fisheries surveys in a set of lakes on the North Slope, as having generally contemporaneous species composition data allowed us to refine the method. However we also included samples collected at the Gilahina River in WRST, and in Igloo Creek in DENA, where historical fisheries data were available, in the initial development phase. Analysis of the Gilahina River samples revealed the presence of DNA from all species that have been documented to occur there (Dolly Varden, rainbow trout, coho salmon, chinook salmon, and slimy sculpin). Similarly, analysis of samples from Igloo Creek revealed the presence of DNA from Arctic grayling and slimy sculpin, the only two species documented in that system. A manuscript based on this work is in review at the journal Molecular Ecology Resources (Menning *et al.*, submitted). We are now in the process of analyzing a large number of samples collected from streams and lakes in both the Central Alaska and Arctic Networks.

The latest effort to arise out of this collaboration has been to design DNA-based methods for the detection of multiple aquatic invasive species, as well as species that are cryptic or otherwise difficult to monitor. The first phase of this project has resulted in the development of mitochondrial markers for the detection of both species of the invasive aquarium plant genus *Elodea* (*canadensis* and *nuttallii*) known to be present in Alaska. Preliminary laboratory work indicates that the method successfully detects both species. In 2016, field crews collected eDNA samples from multiple lakes in WRST, as well as in Kenai Fjords, Lake Clark, and Katmai, in concert with standard “rake” physical surveys for the plant. Although a funding snafu has temporarily halted the laboratory work, we hope to have the

Table 4. List of potentially invasive aquatic species we are developing DNA-based assays for. Note that invasive fish species (underlined) can already be detected using our existing assay. Priority was determined following consultations with state and federal land management agencies.

High priority

American waterweed – *Elodea canadensis* (*present and spreading*)
 Nuttall’s waterweed – *Elodea nuttallii* (*present and spreading*)
Northern pike – *Esox lucius* [S of the Alaska Range] (*present, possibly spreading*)
 Red swamp crayfish – *Procambarus clarkia* (*present, reproduction documented*)
Atlantic salmon – *Salmo salar* (*occasionally detected, reproduction not documented*)
 New Zealand mud snail – *Potamopyrgus antipodarum* (*not yet detected*)

Secondary priority

Zebra mussel – *Dreissena polymorpha* (*not yet detected*)
 Signal crayfish – *Pacifasticus leniusculus* (*not yet detected*)
 Northern red-legged frog – *Rana aurora* (*present, reproduction documented*)
 Whirling disease parasite – *Myxobolus cerebralis* (*not yet detected*)
 Chinese mitten crab – *Eriocheir sinensis* (*not yet detected*)
 Spiny waterflea – *Bythotrephes longimanus* (*not yet detected*)
 Northern Pacific tree frog – *Pseudacris regilla* (*present, reproduction documented*)
 Quagga mussel – *Dreissena bugensis* (*not yet detected*)
American shad – *Alosa sapidissima* (*rarely detected, reproduction not documented*)

results of these analyses in the near future. This work is continuing in 2017. With additional field efforts across multiple parks. Mitochondrial markers for additional species have been designed, but not yet tested (Table 4).

Monitoring stream conditions with time-lapse cameras

In 2012 the Stream Monitoring Program launched an effort to monitor the dates of freeze-up and break-up, as well as obtain continuous qualitative estimates of flow and turbidity in streams and rivers in the CAKN using digital time-lapse cameras. The first camera was deployed on Jack Creek and initially recorded high-quality images once per hour. However, the batteries failed in December. In 2013 we installed higher-quality batteries and reduced the frequency of image collection to once every 4 hours, but again the batteries failed over the winter. In September 2014 we installed very high quality lithium batteries in hopes that image collection could be maintained through the winter. These batteries did last through the winter, however the camera itself was stolen during the summer of 2016, resulting in the loss of a year's worth of photos. We are currently re-thinking the location and attachment method for time-lapse cameras. Once the method is worked out the program hopes to expand the network of cameras across all 3 CAKN parks. This constitutes a very low-cost method of recording qualitative river stage data, as well as monitoring river break-up and freeze-up.

Cumulative stream sampling and additional data sources

Since 2006, the CAKN Stream Monitoring Program has made 819 sampling visits to 186 unique sites across the network. Figure 4 shows the locations of all 186 sites. Individual sites have been sampled from one to 34 times over that period. Not all data types were collected at each visit, although the 4 core water chemistry parameters (temperature, specific conductivity, pH and dissolved oxygen) were collected every time unless the stream was waterless at the time of the site visit. Examination of Figure 6 reveals that some areas of the network are underrepresented, most notably in YUCH. This is partly due to the phased roll-out of the monitoring program, which initially focused on WRST, and then expanded gradually to include DENA and then YUCH. In addition, logistical complications and compliance issues have interfered with efforts to expand sampling in YUCH over the last several years. The program hopes to begin remedying this situation with an increased focus on sampling in YUCH in future years. Other areas that remain underrepresented include the western half of DENA, as well as the far northeastern, southeastern and coastal areas of WRST. This is primarily due to the difficulty and high cost of accessing these areas by helicopter. Not shown in Figure 6 are 12 sites that were sampled in Tetlin National Wildlife Refuge in 2014 as part of a new cooperative effort with the US Fish and Wildlife Service. 12 sites in Tetlin NWR were sampled for eDNA, including both lakes and streams. As part of an ongoing effort to improve the performance and geographic scope of the RIVPACS biological water quality assessment models that the program is developing, as well as to improve modeling of water chemistry regimes across the network, we have been actively engaged in locating and incorporating stream data collected by other agencies and programs. As of 2016, we have begun to

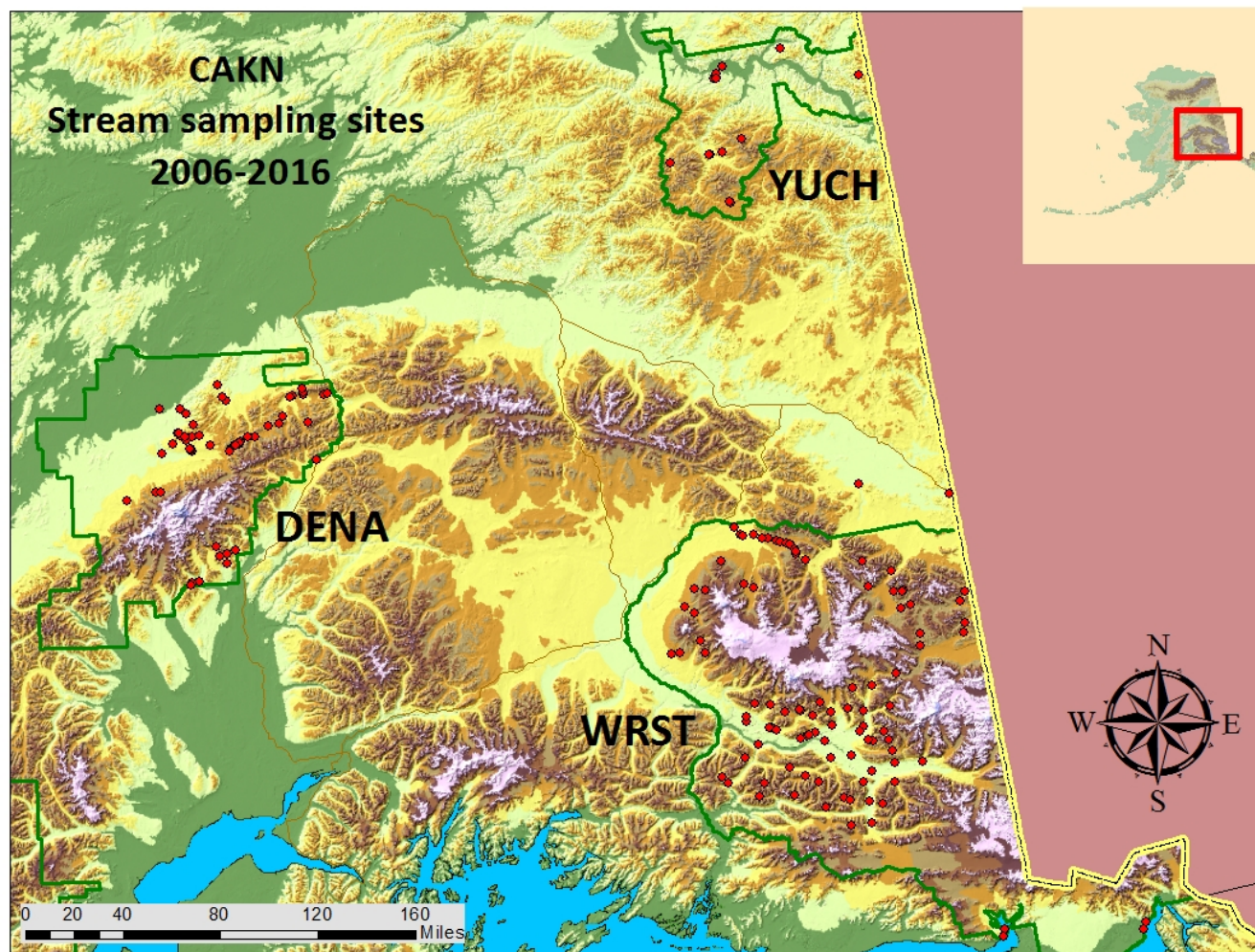


Figure 4. Locations of all sites sampled by the CAKN Stream Monitoring Program since 2006. The majority of sites have been sampled once, but some sites have been sampled as many as 34 times.

incorporate data from two additional sources, as shown in Figure 5. In 2004-2005, the Environmental Protection Agency (EPA) provided funds to the Alaska Department of Environmental Conservation to collect biological, chemical and habitat data from wadeable streams in the Tanana Basin. The field protocols used in this effort, known as the Alaska Monitoring and Assessment Program (AKMAP), were very similar to those that the CAKN Stream Monitoring Program uses (which are largely based on EPA methods), which greatly simplifies the process of combining data from the two data sets. AKMAP data were collected at 44 sites across the Tanana Basin. Only two of these sites are located within the boundaries of CAKN park units. However, all 44 sites are located within the larger geographic scope of the network, meaning that data collected at these sites are ideal for improving modeling at the network

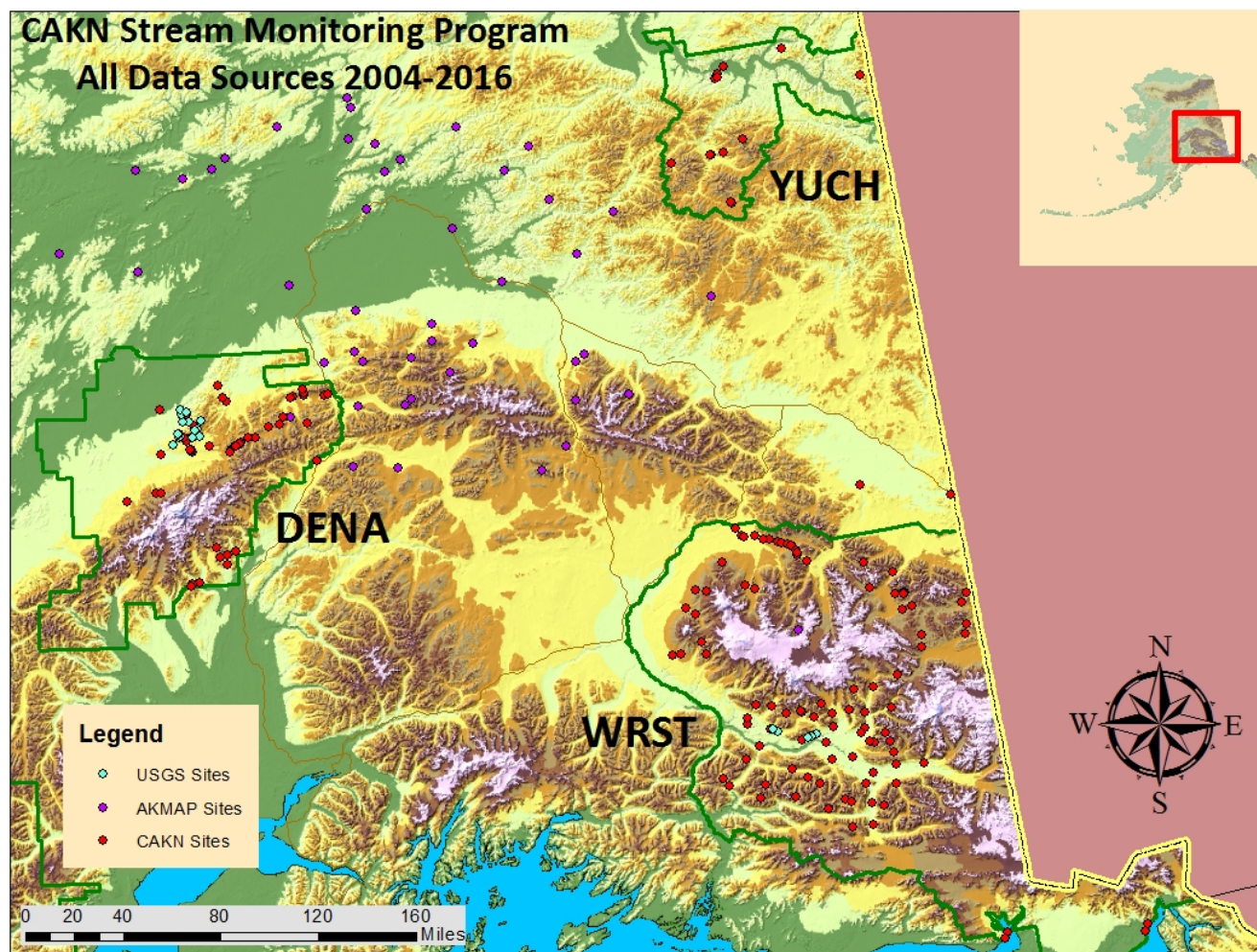


Figure 5. Locations of all data sources being incorporated into analyses for the Stream Monitoring Program through 2016. Sites shown in red are locations where the CAKN has collected data since 2006. Sites shown in blue are locations where data were collected by the USGS along the McCarthy Road and in the Kantishna Hills from 2007-2009. Note that most of the USGS sites have also been sampled by the CAKN. Sites shown in purple are locations where data were collected as part of an EPA-funded pilot project (AKMAP) by the Alaska Department of Environmental Conservation in 2004-2005.

scale. We have also obtained biological, physical and chemical data collected by the US Geological Survey (USGS) at 12 stream sites, 7 in DENA and 5 in WRST (Figure 5). These data were collected from 2007-2009 using protocols developed for the USGS National Water-Quality Assessment Program (NAWQA). Although NAWQA field protocols differ in some respects from protocols used by the EPA and CAKN, the resulting data are fundamentally compatible. Six of the sites in DENA are in streams affected by historical mining activity. Data from these sites will be used to test the sensitivity of the RIVPACS biological assessment models in detecting the effects of past mining on the current condition of stream ecosystems in DENA. These additional sites will also facilitate the detection and analysis of spatial patterns in water chemistry and biodiversity across the network. As of December 2016, we are actively engaged with researchers from the Bureau of Land Management (BLM) and the Alaska Natural Heritage Program to obtain additional data from Tetlin NWR, Yukon Flats NWR and the upper Tanana River Basin.