Hydrology of a Glacial Dominated Coastal River – Johnson River
Lake Clark National Park and Preserve, Alaska

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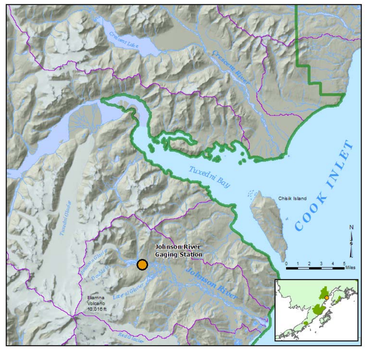


Johnson Glacier and headwaters of the Johnson River

Introduction

Local watershed hydrology is driven by weather factors such as precipitation, temperature and wind, which in turn control surface runoff and glacial flows. The magnitude and timing of stream discharge regulates sediment transport and water quality. Through these interconnections, hydrology is a fundamental driver for aquatic, terrestrial, and nearshore marine systems in the Southwest Alaska Network (SWAN).

As part of the Vital Signs monitoring program, the SWAN anticipates selecting at least one Cook Inlet watershed to monitor. The Johnson River is a USGS National Water Quality Assessment Program study site, and is also a management concern due to a proposed hard rock gold mine on inholdings within its headwaters. Extensive glaciation, high coastal barrier mountains, and locally high precipitation are dominant factors in the surface water hydrology of this 25 mi^2 watershed.

Objectives

- Assess seasonal and annual variation in discharge of a coastal glacial river
- Examine daily and seasonal variation in temperature, specific conductance, pH, and dissolved oxygen
- Investigate correlations, if any, between water quality parameters and flows
- Test the use of a continuously recording multi-parameter water quality probe in SWAN glacial systems.

Methods

In 2003-2004, the Southwest Alaska Network funded the US Geological Survey (USGS) to operate a stream gaging station on the Johnson River in Lake Clark National Park and Preserve (LACL). This station had been maintained during the open water season for the previous eight years through a variety of funding sources. No other gaging stations are currently operating on the west side of Cook Inlet, and it is the only two USGS stream gage currently operating in SWAN parks.

In 2004, SWAN added a continuously recording multi-parameter water quality probe to the gaging station to measure turbidity and the four National Park Service core water quality parameters of temperature, specific conductance, pH, and dissolved oxygen.

Results and Discussion

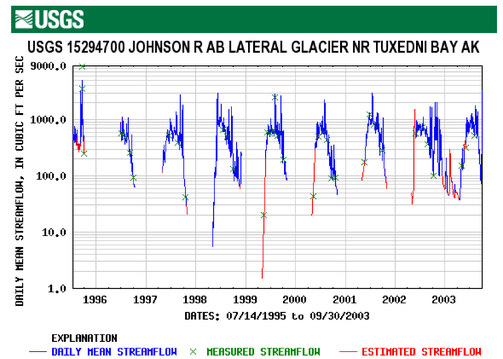
Discharge

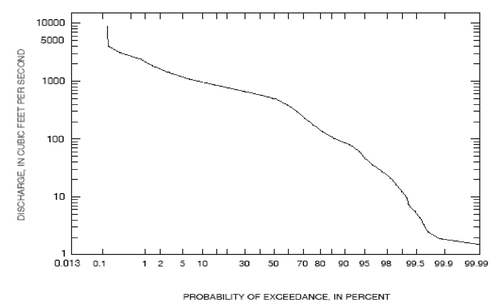
The Johnson River has pronounced daily and seasonal streamflow patterns, and large year-to-year fluctuations in discharge. Since 1995, peak flows have varied from 1,640 cfs in August, 1996, to 11,900 cfs in October, of 2003. Snowmelt and glacial melt provide mid- to late-summer peak flows, whereas rain-on-snow events can generate moderate to severe flooding in a matter of hours. Snow and glacial melt also force daily flow fluctuations, with low flows in the cool mornings, and higher flows in late afternoon when warmer air temperature increases melt.

Based on the flow duration curve for the Johnson River, discharge will exceed 4,000 cfs just over 0.1% of the time, but exceed 40 cfs 95% of the time.

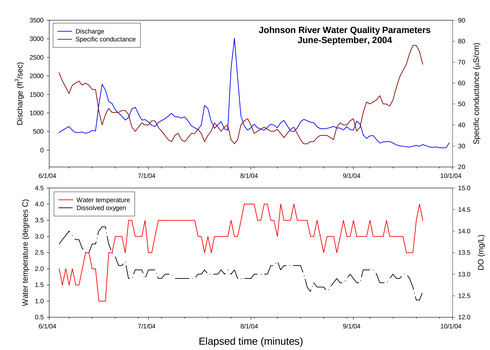
Water Temperature

Water temperature increased over the course of the summer, varying from a daily minimum of 1°C to a daily maximum of 7°C, but showed no consistent relationship with discharge. On a daily cycle, as measured every 15 minutes, water temperature and discharge show an inverse relationship, indicating the strong influence of cold, glacial melt.

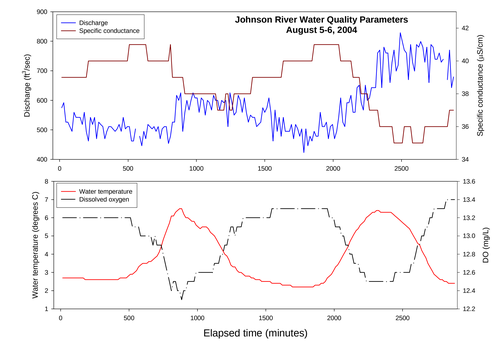




FLOW DURATION CURVE FOR JOHNSON RIVER



Relation between Johnson River daily discharge and daily specific conductance, water temperature and dissolved oxygen.



Relation between discharge, specific conductance, water temperature and dissolved oxygen as measured every 15 minutes.

Specific Conductance

Over the course of the summer, specific conductance, a measure of the types and amounts of dissolved substances in the water, had an inverse relationship with discharge. Low flows are primarily groundwater fed, and thus carry greater amounts of dissolved ions. High flows are fed by snow or glacial melt, or rainfall, and normally have lesser amounts of dissolved constituents.

At a finer scale, with measurements every 15 minutes, specific conductance again showed a reciprocal relationship with discharge.

Dissolved Oxygen

Dissolved oxygen decreased over the 2004 open water period, with the greatest change in June.

Over the course of a day, dissolved oxygen and water temperature showed an inverse relationship. Colder water can hold more dissolved oxygen, and in Alaska, most surface waters are close to saturation. Therefore, water temperature is the primary control on dissolved oxygen in the Johnson River.

Future Plans

In 2005, stream gaging will be funded for the Crescent River rather than the Johnson River. Discharge data on the Johnson River is sufficient to capture overall flow variability. The site has been unstable since a Fall 2003 flood and streambank erosion is likely to prevent future stream gaging at this site. The Crescent River is a larger watershed, with a headwater lake, which more closely matches other proposed monitoring sites. Flow data were collected on the Crescent River in 2003-2004 as part of a special project, increasing our capability to correlate flows between the two systems.

The multi-parameter water quality probe worked well, and will be incorporated in future water quality monitoring.