Fishery Data Series No. 15-12

# Streamflow Data to Support Reservations of Water for Fish and Meadow Creeks in the Big Lake Drainage, Alaska, 2008–2013

by

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May 2015

Alaska Department of Fish and Game Divisions of Sport Fish and Commercial Fisheries

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**Weights and measures (metric)**

| | |
|---|---|
| centimeter | cm |
| deciliter | dL |
| gram | g |
| hectare | ha |
| kilogram | kg |
| kilometer | km |
| liter | L |
| meter | m |
| milliliter | mL |
| millimeter | mm |

**Weights and measures (English)**

| | |
|---|---|
| cubic feet per second | $ft^3/s$ |
| foot | ft |
| gallon | gal |
| inch | in |
| mile | mi |
| nautical mile | nmi |
| ounce | oz |
| pound | lb |
| quart | qt |
| yard | yd |

**Time and temperature**

| | |
|---|---|
| day | d |
| degrees Celsius | °C |
| degrees Fahrenheit | °F |
| degrees kelvin | K |
| hour | h |
| minute | min |
| second | s |

**Physics and chemistry**

| | |
|---|---|
| all atomic symbols | |
| alternating current | AC |
| ampere | A |
| calorie | cal |
| direct current | DC |
| hertz | Hz |
| horsepower | hp |
| hydrogen ion activity (negative log of) | pH |
| parts per million | ppm |
| parts per thousand | ppt, ‰ |
| volts | V |
| watts | W |

**General**

| | |
|---|---|
| Alaska Administrative Code | AAC |
| all commonly accepted abbreviations | e.g., Mr., Mrs., AM, PM, etc. |
| all commonly accepted professional titles | e.g., Dr., Ph.D., R.N., etc. |
| at | @ |
| compass directions: | |
| east | E |
| north | N |
| south | S |
| west | W |
| copyright | © |
| corporate suffixes: | |
| Company | Co. |
| Corporation | Corp. |
| Incorporated | Inc. |
| Limited | Ltd. |
| District of Columbia | D.C. |
| et alii (and others) | et al. |
| et cetera (and so forth) | etc. |
| exempli gratia (for example) | e.g. |
| Federal Information Code | FIC |
| id est (that is) | i.e. |
| latitude or longitude | lat or long |
| monetary symbols (U.S.) | $, ¢ |
| months (tables and figures): first three letters | Jan,...,Dec |
| registered trademark | ® |
| trademark | ™ |
| United States (adjective) | U.S. |
| United States of America (noun) | USA |
| U.S.C. | United States Code |
| U.S. state | use two-letter abbreviations (e.g., AK, WA) |

**Mathematics, statistics**

| | |
|---|---|
| *all standard mathematical signs, symbols and abbreviations* | |
| alternate hypothesis | $H_A$ |
| base of natural logarithm | *e* |
| catch per unit effort | CPUE |
| coefficient of variation | CV |
| common test statistics | (F, t, $\chi^2$, etc.) |
| confidence interval | CI |
| correlation coefficient (multiple) | R |
| correlation coefficient (simple) | r |
| covariance | cov |
| degree (angular ) | ° |
| degrees of freedom | df |
| expected value | *E* |
| greater than | > |
| greater than or equal to | ≥ |
| harvest per unit effort | HPUE |
| less than | < |
| less than or equal to | ≤ |
| logarithm (natural) | ln |
| logarithm (base 10) | log |
| logarithm (specify base) | $log_2$, etc. |
| minute (angular) | ' |
| not significant | NS |
| null hypothesis | $H_O$ |
| percent | % |
| probability | P |
| probability of a type I error (rejection of the null hypothesis when true) | α |
| probability of a type II error (acceptance of the null hypothesis when false) | β |
| second (angular) | " |
| standard deviation | SD |
| standard error | SE |
| variance | |
| population | Var |
| sample | var |

# *FISHERY DATA SERIES NO. 15-12*

# STREAMFLOW DATA TO SUPPORT RESERVATIONS OF WATER FOR FISH AND MEADOW CREEKS IN THE BIG LAKE DRAINAGE, ALASKA, 2008–2013

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May 2015

This report was prepared by Thomas Cappiello under Alaska Sustainable Salmon Fund Projects 45868, 45891, 45523, and 45634 from the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, administered by the Alaska Department of Fish and Game. The statements, findings, conclusions, and recommendations are those of the author and do not necessarily reflect the views of the National Oceanic and Atmospheric Administration or the U.S. Department of Commerce.

This investigation was partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Projects F-10-21 to F-10-29.

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*This document should be cited as:*
*Cappiello, T. 2013. Streamflow data to support reservations of water for Fish and Meadow Creeks in the Big Lake drainage, Alaska, 2008–2013. Alaska Department of Fish and Game, Fishery Data Series No. 15-12, Anchorage.*

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# ABSTRACT

Fish and Meadow Creeks, located in the Big Lake drainage near Wasilla, Alaska, support anadromous fish species important to commercial, personal use, and recreational fisheries. Streamflow data needed to support reservation of water applications were collected for 5 years. Two reaches were delineated on each creek. A continuous-recording gaging station was deployed on one reach of each creek to determine mean daily flow and other flow metrics. For the other reach, a discharge station was established where only instantaneous discharge was measured. Simple linear regression of discharge measurements from the gage and the discharge station was used to determine the daily mean flow record for the non-gaged reach on each creek. Both gages operated from 16 July 2008 to 30 September 2013 and discharge was measured periodically at all stations during this period. Daily and monthly mean, monthly flow exceedance, and mean annual flows were calculated for all four reaches. All sites exhibited similar moderate seasonal and annual variability in flows. Monthly mean flows were typically highest during the spring and fall, and lowest during winter; however, high flows were absent between spring 2009 and spring 2012.

Key words: Fish Creek, Meadow Creek, Big Lake, streamgage, discharge, reservation of water, instream flow

# INTRODUCTION

Alaska's rivers and lakes support some of North America's most viable and productive salmon fisheries. Over 17,000 streams, rivers, or lakes have been identified throughout the state as being important for spawning, rearing, or migration of anadromous fish (Johnson and Coleman 2014). Fish migration, spawning, rearing, and ultimately production in these water bodies depend on sufficient seasonal quantities of water. Demand for water to support hydroelectric power generation, petroleum production, mining, water supply (including out-of-state export), residential uses, forestry, agriculture, and other projects have the potential to modify the naturally occurring instream flows to which fish have adapted and are dependent upon (Poff et al. 1997).

The Fish and Game Act requires the Alaska Department of Fish and Game (ADF&G) to "manage, protect, maintain, improve, and extend the fish, game and aquatic plant resources of the state in the interest of the economy and general well-being of the state" (AS 16.05.020). One mechanism ADF&G uses to fulfill its mandate is to reserve water in rivers and lakes for fish and wildlife. An appropriation of water that remains within a river is legally defined under Alaska law (AS 46.15.145) and regulations (11 AAC 93.970) as a reservation of water. To reserve water, an application with supporting data and analyses must be submitted to the Alaska Department of Natural Resources (DNR). A minimum of 5 years of daily mean flow data is typically required by DNR to quantify instream flow requirements within an application.

The State of Alaska Legislature amended the Alaska Water Use Act in 1980 to allow instream flows to be legally reserved by a private individual, group, or government agency to maintain specific flow rates in a river or volumes and water levels in a lake during specified time periods for one or a combination of 4 types of uses:

- protection of fish and wildlife habitat, migration, and propagation;
- recreation and parks purposes;
- navigation and transportation; and
- sanitary and water quality purposes.

Priority dates for reservation of water applications are based on the date that they are accepted by DNR. Alaska water law is based on the doctrine of prior appropriation, also known as "first in time, first in right." According to the rules of prior appropriation, the right to the requested amount of water is first given to the appropriator who has the earliest priority date to beneficially

use the water. Senior water right holders have a legal standing to assert their right against conflicting uses of water from others who do not have a water right or who are junior in priority.

The goal of this project was to collect and analyze the hydrological data necessary to quantify and protect instream flows in Fish and Meadow Creeks (Figure 1). These streams support important anadromous and resident fish populations and are deemed a high priority for receiving instream flow protection by both ADF&G and the Matanuska-Susitna Basin Salmon Habitat Partnership (2008). Streamflow data collected during this project will be used to file new and update existing reservation of water applications.

Fish and Meadow Creeks are the major streams in the Big Lake drainage. This lake system is a major sockeye salmon producing system in Cook Inlet and supports commercial, subsistence, and personal use fisheries (Chlupach and Kyle 1990; Sweet et al. 2004). Extensive efforts to enhance sockeye salmon in the Big Lake drainage began in 1976 in response to low escapements of wild stocks (Chlupach and Kyle 1990; Engel and Vincent-Lang 1992; Litchfield and Willette 1992; Sweet et al. 2004). The state operated a coho and sockeye salmon hatchery on Meadow Creek from 1975 to 1993. After the hatchery was closed, the Cook Inlet Aquaculture Association (CIAA) took over the enhancement program but reared the sockeye at other hatcheries. Although the root cause of the sockeye salmon decline is unknown, one explanation is an increase in biological oxygen demand in Big Lake causing anoxic conditions in the hypolimnion (Litchfield and Willette 2002). Another possible cause was poor or improperly installed fish passage facilities at a small dam created by ADF&G in 1969 at the outlet of Big Lake. Fish Creek, Big Lake, and Meadow Creek are on the Alaska Clean Water Actions program list of high-priority streams due primarily to poor water quality and concerns over fish habitat integrity.

In 1988, ADF&G filed reservation of water applications for two reaches[1] on Fish Creek and one reach on Meadow Creek. Streamflows requested in these applications were based on U.S. Geological Survey (USGS) estimates of mean annual and monthly flows determined by regional hydrological models and analyses and supported by sporadic discharge measurements made by USGS on the same reaches between years 1974 and 1981. The discharge measurements made by USGS also targeted low flows and therefore represented a narrow range of natural variability. Also, there were no suitable gage records from other streams to which these measurements could be correlated for synthesizing a 5-year record of daily mean flows. Therefore, DNR requested, and ADF&G agreed, that 5 years of site-specific streamflow data was needed before adjudicating these applications.

# OBJECTIVE

The objective of the study was to collect and analyze site-specific hydrological data needed to amend pending reservation of water applications filed for Fish and Meadow Creeks, and prepare and submit a new application for a reservation of water to sustain fish production in an additional reach of Meadow Creek.

[1] For reservations of water, reaches are generally defined such that instantaneous flows do not differ more than approximately 10% from the point of measurement to the upstream and downstream boundaries. This definition may differ somewhat from reach definitions found in the literature or in other studies.

**Tasks**

1. Install and maintain a stream-gaging station to estimate daily mean flows for 5 years on one reach in Fish Creek and one reach in Meadow Creek.

2. Establish a discharge station (where only measurements of instantaneous discharge will be made) on a reach adjacent to the gaged reach in Fish Creek and Meadow Creek. Develop a simple linear regression model between discharge measurements made at the gaging stations and discharge stations to estimate mean daily flows for the non-gaged reaches.

# STUDY AREA

## FISH CREEK

Fish Creek is a slightly tannic stream that flows out of Big Lake and into Knik Arm (Figure 2). The original reservation of water application filed in 1988 established what was referred to as the Lower and Upper reaches, which are designated Reach A and B for this study. Reach A extends from the point where Fish Creek enters Knik Arm upstream to the confluence with Threemile Creek. Reach B continues from the upstream boundary of Reach A to the outlet of Big Lake. Most of the surrounding land is privately owned, and the remainder is owned by the State of Alaska and the Matanuska-Susitna Borough.

To assess streamflow in Reach A, a gage site was selected 1.2 km upstream from the Lewis Loop Road crossing where CIAA and ADF&G operate a fish weir. This site was on private land and has desirable qualities for gaging. An annual lease to use and access this property for gaging (in addition to that for the weir) was established on July 1, 2008. For Reach B, a discharge station (where only instantaneous discharge is measured and no gage is installed) was established at the Big Lake Road bridge crossing.

## MEADOW CREEK

Meadow Creek (Figure 3) originates from a poorly developed drainage network that has been formed by periods of glaciations (Reger and Updike 1983) and possibly a catastrophic outburst from a large paleolake known as Lake Ahtna in the Copper River Valley (Weidmer et al 2010). This area is characterized by a high density of lakes, wetlands, and short, connective stream segments formed at the terminus of overlapping glacial moraines. This “lake complex” area includes Meadow Lakes, Nancy Lake, and Big Lake and is a targeted conservation area in the strategic plan of the Matanuska-Susitna Basin Salmon Habitat Partnership (2008). Meadow Creek above Lucille Creek serves as a groundwater drain from these lakes and infiltration from precipitation and snow melt (Kikuchi 2013). Most of the land in the drainage is privately owned, with a smaller portions owned by the state of Alaska and Matanuska-Susitna Borough.

The reservation of water application filed in 1988 established a 7.6 km reach (Reach A) on Meadow Creek from Big Lake to the confluence of Lucille Creek (Figure 3). In July 2008, a gage site was established in this reach near the abandoned Big Lake Hatchery, about 150 meters downstream from the South Beaver Lake Road crossing. This site was selected because of relative ease of access, location on State land, and suitability for a gage. The United States Fish and Wildlife Service had intended to operate a continuous stream gage at this site and had established benchmarks, but the project was abandoned due to lack of funding.

After a reconnaissance of the area in May 2008, Reach B was designated from the confluence of Lucille Creek upstream 4.2 km to the confluence of an unnamed tributary. (On some maps the portion of Meadow Creek from Lucille Creek upstream to Herkimer Lake is named Little Meadow Creek.) A discharge station was established at a suitable location approximately 200 m downstream from the Parks Highway crossing.

# METHODS

## GAGING AND DISCHARGE STATIONS

Gage installation and data collection techniques followed USGS standards and guidelines (Carter and Davidian 1968; Rantz et al. 1982). Specific procedures that were followed for stream-gaging and data management during this study are described and summarized in Klein (2013). The preferred location for a gage is in a uniform river reach with a stable hydraulic control downstream and nonturbulent flow so that river stage may be accurately surveyed when instantaneous discharge is measured. Ideally, the site should also have a stable relationship between water surface elevations and flow.

Surface water elevation or stage and measurements of instantaneous discharge are essential data components for computing streamflow. A continuous (15 min interval) record of stage is obtained by installing instruments that record water depth as a proxy to water-surface elevation relative to an established datum on land. Discharge is measured throughout the year at a range of flows to define the stage–discharge relationship (rating curve) and to detect and accommodate any possible changes or shifts to this relationship over time.

Each gage was located where stable channel or section controls presumably existed. To avoid backwater, the gage at Fish Creek was installed just downstream of the sites where weirs for juvenile and adult salmon were annually installed. Periodic cleaning of the weirs posed some stage fluctuations throughout the day, but the potential intra-day affects were assumed negligible for accurate daily mean flow calculations. The Meadow Creek gage was installed in a section with relatively slow water, which was not ideal, but the site was the most practical that could be found that had desirable access and was hydrologically representative of the designated reach.

At both gaging stations, a Northwest Instrumentation[2] Aquistar PT2X (5 pounds per square inch gage) pressure transducer and recorder was housed in 1-1/4" pipe secured to the stream bed and/or bank with pipe brackets and rebar driven into the bank. A staff gage was installed in close proximity to each gage as a reference gage to compare to transducer readings. The transducers were programmed with an appropriate offset to correspond with the staff gage reading. Three separate reference marks (RM), each consisting of a lag screw driven into the base of a tree, were established near each gage. One of the RMs was assigned an arbitrary datum elevation of 10 ft. The elevations (relative to this arbitrary datum) of the staff gage, water surface at the gage, the top of the staff gage plate, and remaining RMs were determined using standard differential surveying techniques (Kennedy 2010). These elevations were checked annually or when some event such as a flood had occurred that may have altered any of the gage components. If differences occurred, they were noted and corrected immediately in the field or later in the analysis phase.

[2] Product names used in this report are included for scientific completeness but do not constitute endorsement.

Flows within and sometimes among watersheds often differ in magnitude in a predictable fashion. Gaging is a data-intensive process that requires expensive equipment and demands personnel time for analysis. One way to efficiently obtain daily mean flow records for multiple areas within a watershed is to establish a gaging site with additional discharge stations where only instantaneous flow is measured. A mathematical relationship can then be developed between flows at the gage and the discharge station.

For each gage in this study, one discharge station was established for determining the relationship of flows on an adjacent reach. Simple linear regression between discharge measurements made at the gage and the corresponding discharge station was used to estimate mean daily flows for the non-gaged reach. Three guidelines were followed to help ensure sufficient data collection:

- A minimum of 10 discharge measurements were made at each gage and discharge station per year.
- Discharge measurements were taken throughout the natural range of flows and throughout the year, for at least two consecutive years.
- Discharge measurements were taken at all stations within the shortest time frame practical and during stable flows.

Similar to USGS, ADF&G uses a unique number to identify each data collection station, whether it is a stream site, lake, reservoir, spring, or well. This number is unique, applying specifically to a given station and to no other. Once this number is assigned, it is usually retained for that station indefinitely and assists with future reference. The numbering system, however, does not distinguish the region or whether the station has a gage (allowing continuous records) or is limited to only partial records. Reaches within a stream are designated alphabetically in an upstream direction. Station identification numbers and reach designations were assigned to each station in this study as follows:

| Station name (type) | ADF&G station number | Reach designation (original application) | Latitude | Longitude |
|---|---|---|---|---|
| Fish Creek (gage) | 12001 | Reach A (Lower) | 61.44749 | -149.8235 |
| Fish Creek (discharge) | 12002 | Reach B (Upper) | 61.53442 | -149.827 |
| Meadow Creek (gage) | 12101 | Reach A (none) | 61.56191 | -149.8268 |
| Meadow Creek (discharge) | 12102 | Reach B (Little Meadow) | 61.57663 | -149.7304 |

Coordinates based on NAD83

## DISCHARGE MEASUREMENTS

Discharge is defined as the volume rate of flow of water (or streamflow) and is conventionally reported in cubic feet per second ($ft^3/s$; Buchanan and Somers 1969). Discharge is determined by measuring the average velocity, depth, and width of subsections across the stream. Most discharge measurements were taken using a top-setting wading rod and mechanical current meter, either a Price Type AA or Pygmy depending on flow conditions. An AquaCalc electronic digital counter made by JBS Energy was used to record the transect parameters, count meter revolutions, and automatically calculate discharge. When stream stage was too high to wade, a StreamPro Acoustic Doppler Current Profiler, made by Teledyne RD Instruments, was used to

measure discharge according to product manuals and USGS guidelines (Simpson 2001; Oberg et al. 2005).

Discharge measurements during ice cover were made following procedures in Rantz et al. (1982). A gas-powered auger was used to drill holes through the ice cover along a transect. A vertical-axis velocity meter on a standard top-setting wading rod was used to measure discharge in each subsection represented where a hole was drilled. Discharge was calculated in the same manner as the open-water measurement but multiplied by a standard ice roughness factor of 0.92 (Rantz et al. 1982; Nolan and Jacobson 2000).

Each discharge measurement was assigned a quality rating based on a subjective estimate of error (percent from the true value) as "poor" (> 8%), "fair" (5-8% ), "good" (2-5%), and "excellent" (< 2%). USGS commonly uses this approach, which is based on historical analysis of many factors such as cross-section uniformity, velocity uniformity, stream bed conditions, and number of subsections measured (Sauer and Meyer 1992). These quality ratings are primarily used to assist with the development of rating curves and to help estimate daily records during winter when stage values are not available.

## SITE VISITS

Site visits were scheduled to occur approximately twice per month during the open-water period and two to three times to each site during the winter. Site visits were made to download data from the data loggers, measure discharge, and perform routine gage maintenance. ADF&G contracted staff from the Wasilla Soil and Water Conservation District (WSWCD) to measure discharge, read staff gages, download data, and provide general gage maintenance during open-water periods. ADF&G staff, with the assistance of WSWCD, made all winter site visits and occasional visits during open water for training, data collection quality checks, surveys, and gage installation and removal.

## STREAMFLOW RECORDS COMPUTATION

Stage readings recorded by the transducers were converted to discharge using a developed stage-discharge relationship (also referred to as a rating curve). All of the computations were performed by a consultant who followed USGS methods. The consultant developed rating curves and applied appropriate gage height corrections and shifts, if necessary, and computed daily mean values for each "water year" (WY)[3]. For periods with missing or unusable stage values, such as during winter ice-cover, mean daily flows were estimated by linear interpolation or other USGS standard protocols (Rantz et al. 1982; Melcher and Walker 1992; Hicks and Healy 2003) that incorporate climate variability into flow estimates.

A simple linear regression model was used to estimate the relationship between streamflow at the gage stations and the corresponding discharge stations for each creek. The discharge stations were considered as the dependent variable; instantaneous discharge measurements from the discharge station were regressed against the corresponding discharge measured at the gage. The data were not temporally stratified.

[3] A "water year" is a hydrological term defined as the 12-month period from October 1 for any given year through September 30 of the following year.

Daily mean flow records computed for each site were then analyzed by a series of SAS® software[4] (version 9.2 for Microsoft Windows) programs to estimate the annual, monthly, and mean of daily mean flows and flow duration statistics for specified time periods. An overall mean annual flow was estimated as the mean of all daily mean flow values over all complete water years of record. Monthly mean flows were estimated as the mean of daily mean flows for all complete months of the calendar over the entire period of record. Flow duration analyses provide an estimate of the percentage of time (termed "exceedance") a given daily mean flow was equaled or exceeded within the distribution of daily mean flows by calendar month (for all complete months within the study period). For example, if a mean daily flow of 10 $ft^3/s$ has an exceedance of 10% in April, that flow was equaled or exceeded 10% of all days of all months of April within the period of record. A 50% exceedance flow is equal to the median flow. Comparing the flows at high and low exceedance helps identify the range of variability and degree of stability of flows for various time frames.

Streamflow values in this report are presented according to USGS guidelines (http://wdr.water.usgs.gov/current/documentation.html#sqw, accessed January 7, 2014). Values of daily mean discharge are shown to the nearest hundredth $ft^3/s$ for discharges of less than 1 $ft^3/s$; to the nearest tenth between 1.0 and 10; to whole numbers between 10 and 1,000 $ft^3/s$; and to three significant figures above 1,000 $ft^3/s$. The number of significant figures used is based solely on the magnitude of the discharge value. Summary statistics included leap days (29February) as an additional 28 February. During this study, only water year 2012 had a leap day.

# RESULTS

## FISH CREEK

### Gage station

The Fish Creek gage operated from 16 July 2008 through 30 September 2013, a period that included 5 complete water years (WY2009-WY2013). There were no periods of interrupted stage records during open water; however, Cook Inlet Aquaculture Association staff installed a temporary salmon smolt weir downstream of the gage from 10 May to 2 July 2010, which caused some backwater effects at the gage. The rating for those days affected by the backwater was shifted based on the estimated stage increase.

During the period of record, including winter, 64 discharge measurements were made at the gage site ranging from 9.9 $ft^3/s$ to 232 $ft^3/s$ (Table 1). Mean of daily mean flows ranged from 16 to 247 $ft^3/s$ (Table 2). Daily mean flows ranged from 6.6 $ft^3/s$ on 13 March 2011, to 652 $ft^3/s$ on 9 September 2012 (Appendix A1-A5). Monthly mean flows and exceedance values reflected moderate variability within and among months (Table 3). Monthly and seasonal trends varied throughout the period of record and were typically higher during the spring from snowmelt and in the fall when most precipitation usually occurs (Figure 4). Mean annual flows ranged from 30 $ft^3/s$ in WY2010 to 104 $ft^3/s$ in WY2013 (Table 4).

[4] SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc. in the USA and other countries. ® indicates U.S. registration.

### Discharge station

At the Fish Creek discharge station, discharge was measured 74 times ranging from 5.1 $ft^3/s$ to 116 $ft^3/s$ (Table 5). More discharge measurements were made than originally planned at this site because the site remained ice free for much of the winter and provided a good opportunity to collect additional measurements while most of the stream was ice-covered. The simple linear regression between the Fish Creek stations resulted in a positive relationship, with a coefficient of determination ($r^2$) of 0.91 (Appendix B1). A record of the mean of daily mean flow (mean of all unique calendar days) was calculated using the regression parameters (Table 6). Because the record is derived from the regression, monthly mean and exceedance values (Table 7) reflect the same inter- and intra-annual flow trends of the gage records. Mean annual flows ranged from 21 $ft^3/s$ in WY2010 to 62 $ft^3/s$ in WY2013 (Table 4).

## MEADOW CREEK

### Gage station

The Meadow Creek gage operated from 16 July 2008 through 30 September 2013. An interruption in stage records during open water occurred from 4 July through 6 August 2012. This interruption was caused by a battery that had leaked and destroyed the transducer circuitry. The daily mean flows for these days were estimated based primarily on interpolation and flow trends from the Fish Creek gage. Staff from the United States Fish and Wildlife Service installed a temporary salmon smolt weir downstream of the gage 31 May to 22 June 2013, which caused some backwater issues at the gage. As with the similar occurrence on Fish Creek, the rating for those days was shifted to accommodate the increase in stage caused by the weir.

During the period of record including winter, 70 discharge measurements were made at the gage site ranging from 2.5 $ft^3/s$ to 91.5 $ft^3/s$ (Table 8). Daily mean flows ranged from 1.5 $ft^3/s$ on 23–25 February 2011 to 244 $ft^3/s$ on 23 September 2012 (Appendix A6-A10). Mean of daily mean flows ranged from 5.6 to 83 $ft^3/s$ (Table 9). Monthly mean and exceedance flows (Table 10) reflected low variability within and among months and were typically higher during the spring and fall but to a much lesser extent than at Fish Creek (Figure 5). Mean annual flows ranged from 13 $ft^3/s$ in WY2010 and WY2011 to 45 $ft^3/s$ in WY2013 (Table 4).

### Discharge station

Discharge was measured 65 times at the discharge station and ranged from 2.6 $ft^3/s$ to 36.2 $ft^3/s$ (Table 11). A positive linear relationship with a coefficient of determination ($r^2$) of 0.88 existed between the Meadow Creek stations (Appendix B2). A record of mean of daily mean flow was calculated by first developing a mean daily record using the regression parameters, then averaging the flow for each calendar day (Table 12). Because the record is derived from the regression, monthly mean and exceedance values (Table 13) are proportionate to and reflect the same inter- and intra-annual flow trends of the gage records. Mean annual flows ranged from 6 $ft^3/s$ in WY2011 to 17 $ft^3/s$ in WY2013 (Table 4).

# DISCUSSION

The Big Lake drainage provides important habitat for many fish species at various life stages. Prior to this project, empirical streamflow data had been limited to sporadic measurements of instantaneous discharge by USGS between 1974 and 1984, at or near the same locations used in this study. This project successfully collected 5 years of continuous streamflow data to support

reservation of water applications for two reaches representing the entire length of Fish Creek and two reaches of Meadow Creek.

Overall, flows at all sites were relatively stable exhibiting narrow ranges between extremes and low seasonal variability during the 5 years of this study. Stable flows probably reflected the nature of the drainage, which has low elevation relief, high lake density, and substantial amounts of groundwater input. A few notable extreme flows did occur. There was a period of low precipitation during the first 3 years of this study. During 2010, below-normal fall precipitation followed by a cold winter with little snow cover appeared to have led to extreme low winter and spring flows. In contrast, during the fall of 2012 and 2013, high or above-average precipitation occurred, elevating seasonal flows. High snow accumulation and rapid spring melt in 2012 and 2013 led to the high spring flows. This alteration of dry and wet periods is also reflected in the mean annual flows for all sites (Table 4). Water years 2009 through 2011 were fairly consistent and usually below the 5-year mean, with WY2012 being slightly higher and WY2013 being the highest of all—nearly double the overall mean annual flow for the study period.

Discharge measurements under ice are typically deemed "poor" due to a number of sources of uncertainty. For example, sometimes all of the flow cannot be directly observed or measured, flowing water can sometimes be pushed out of the channel by the weight of ice cover, and groundwater inflows can change dramatically along stream reaches depending on climatological and hydrological conditions. The presence of off-channel, shallow wetlands in which the water freezes during the winter contributes to winter flows at varying and somewhat unpredictable degrees. Winter discharge measurements proved difficult to obtain primarily due to access and staff scheduling. The Fish Creek discharge station, however, was not covered in ice for most of the winter, providing some "fair" (rather than "poor") winter discharge measurements. Some winter discharge measurements between the discharge and gage stations seemed to exhibit greater variability than would normally be expected from measurement error.

The winter flows measured during 2011 were surprisingly low for a groundwater-fed stream and underline the importance of protecting winter flows for incubating eggs and overwintering adult and juvenile fish. Further study is needed to assess how these extreme or varied seasonal flow patterns may affect fish survival. Influence of groundwater can be complex; the connectivity of groundwater to surface water also should be studied further. The population in this part of the Matanuska-Susitna Borough will undoubtedly grow, leading to an increased demand for water, which could impact local hydrology and fish habitat. Reservation of water flow requests during winter should take uncertainty into account and incorporate a precautionary approach. Site-specific winter flows should be more thoroughly assessed to determine whether there is a need for out-of-stream water uses on these streams.

# ACKNOWLEDGEMENTS

Funding for this project was secured through several Alaska Sustainable Salmon Fund grants submitted by the author. The following Wasilla Soil and Water Conservation District staff conducted most of the essential fieldwork under contract and provided services as in-kind matching: Catherine Inman, Brianne Blackburn, Louisa Branchflower, Carolyn Weimer, Becky McNeil, John Kelly, Julius Thompson, Joseph Phillips, and Chuck Kaucic. Under contract, Bruce Bigelow and Brittany Tripp of Waterwalkers Streamflow Monitoring worked up the computations for the gages and provided services as in-kind matching. Anton Antonovich provided biometric support. Jason Mouw, ADF&G, occasionally assisted with fieldwork and advice.

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# TABLES AND FIGURES

Table 1.–Summary of instantaneous discharge measurements taken at the Fish Creek gaging station.

| Date | Start time | End time | Discharge ($ft^3/s$) | Staff gage (ft) | Quality rating |
|---|---|---|---|---|---|
| 7/16/2008 | 1325 | 1417 | 25.0 | 1.37 | Fair |
| 7/25/2008 | 1409 | 1509 | 89.5 | 1.84 | Fair |
| 8/1/2008 | 1159 | 1238 | 87.7 | 1.82 | Fair |
| 8/6/2008 | 1357 | 1447 | 62.7 | 1.70 | Fair |
| 8/21/2008 | 1138 | 1228 | 40.5 | 1.50 | Fair |
| 9/11/2008 | 1126 | 1235 | 45.7 | 1.54 | Good |
| 9/29/2008 | 1335 | 1419 | 73.7 | 1.78 | Fair |
| 1/30/2009 | 1134 | 1213 | 25.2 | ice | Poor |
| 3/9/2009 | 1200 | 1230 | 23.4 | ice | Poor |
| 5/15/2009 | 1058 | 1128 | 81.8 | 1.83 | Fair |
| 6/1/2009 | 1033 | 1110 | 54.0 | 1.70 | Fair |
| 6/12/2009 | 0949 | 1053 | 36.3 | 1.54 | Fair |
| 6/22/2009 | 1146 | 1239 | 31.7 | 1.48 | Fair |
| 7/17/2009 | 928 | 1019 | 14.7 | 1.27 | Poor |
| 7/31/2009 | 1048 | 1135 | 18.6 | 1.25 | Fair |
| 8/13/2009 | 0932 | 1010 | 16.4 | 1.24 | Fair |
| 8/24/2009 | 1615 | 1652 | 25.8 | 1.38 | Fair |
| 9/14/2009 | 1010 | 1103 | 21.5 | 1.32 | Fair |
| 10/13/2009 | 1013 | 1107 | 38.4 | 1.54 | Fair |
| 1/29/2010 | 1133 | 1159 | 9.9 | ice | Poor |
| 5/4/2010 | 1004 | 1038 | 59.7 | 1.60 | Fair |
| 6/2/2010 | 1159 | 1240 | 23.4 | 1.38 | Fair |
| 6/10/2010 | 1416 | 1453 | 19.8 | 1.47 | Fair |
| 6/21/2010 | 1037 | 1107 | 22.3 | 1.50 | Fair |
| 7/1/2010 | 1248 | 1328 | 22.4 | 1.60 | Fair |
| 7/19/2010 | 1212 | 1246 | 21.7 | 1.24 | Fair |
| 8/23/2010 | 1116 | 1152 | 42.0 | 1.44 | Poor |
| 9/14/2010 | 1215 | 1241 | 44.2 | 1.48 | Fair |
| 10/6/2010 | 1324 | 1345 | 26.3 | 1.33 | Fair |
| 4/27/2011 | 1126 | 1153 | 73.9 | 1.64 | Poor |
| 5/20/2011 | 1212 | 1245 | 39.8 | n/a | Fair |
| 6/4/2011 | 1303 | 1358 | 29.1 | 1.24 | Fair |
| 6/21/2011 | 936 | 1037 | 29.2 | 1.26 | Fair |
| 7/5/2011 | 1122 | 1204 | 17.5 | 1.12 | Fair |
| 7/19/2011 | 1046 | 1131 | 23.5 | 1.22 | Fair |

-continued-

Table 1.–Page 2 of 2.

| Date | Start time | End time | Discharge ($ft^3/s$) | Staff gage (ft) | Quality rating |
|---|---|---|---|---|---|
| 8/8/2011 | 1344 | 1424 | 43.9 | 1.42 | Fair |
| 8/24/2011 | 1219 | 1258 | 48.5 | 1.46 | Fair |
| 9/6/2011 | 1353 | 1425 | 39.0 | 1.36 | Fair |
| 9/23/2011 | 1235 | 1305 | 21.2 | 1.18 | Fair |
| 10/24/2011 | 1226 | 1301 | 32.6 | 1.32 | Fair |
| 12/15/2011 | 1236 | 1257 | 39.2 | ice | Poor |
| 2/17/2012 | 1158 | 1229 | 20.9 | ice | Poor |
| 5/1/2012 | 0853 | 0909 | 206.4 | 2.49 | Good |
| 5/8/2012 | 1234 | 1309 | 119.0 | 2.12 | Fair |
| 5/22/2012 | 1210 | 1243 | 68.0 | 1.78 | Fair |
| 6/7/2012 | 1204 | 1238 | 61.3 | ice | Fair |
| 6/21/2012 | 1016 | 1103 | 55.6 | 1.73 | Fair |
| 6/28/2012 | 1045 | 1133 | 54.6 | 1.68 | Fair |
| 7/14/2012 | 927 | 1021 | 33.4 | 1.48 | Fair |
| 8/11/2012 | 1648 | 1734 | 29.7 | 1.44 | Fair |
| 8/23/2012 | 1241 | 1332 | 37.6 | 1.48 | Fair |
| 9/6/2012 | 1013 | 1059 | 60.3 | 1.70 | Fair |
| 2/14/2013 | 1218 | 1242 | 37.0 | ice | Poor |
| 5/17/2013 | 1201 | 1212 | 232.0 | 2.67 | Good |
| 5/24/2013 | 1151 | n/a | 201.5 | 2.47 | Fair |
| 6/11/2013 | 0934 | 1032 | 108.2 | 2.00 | Fair |
| 6/21/2013 | 1010 | 1037 | 59.0 | 1.69 | Fair |
| 6/24/2013 | 1304 | 1340 | 54.9 | 1.62 | Fair |
| 7/2/2013 | 2249 | 2301 | 50.9 | 1.62 | Poor |
| 7/9/2013 | 1711 | 1749 | 44.9 | 1.58 | Poor |
| 7/30/2013 | 1113 | 1146 | 44.9 | 1.57 | Poor |
| 8/2/2013 | 1127 | 1158 | 23.0 | 1.33 | Fair |
| 8/23/2013 | 1224 | 1255 | 96.3 | 2.00 | Fair |
| 9/16/2013 | 1109 | 1142 | 206.6 | 2.61 | Fair |
| 9/26/2013 | 1439 | 1514 | 228.9 | 2.65 | Fair |

Table 2.–Mean of daily mean flows ($ft^3/s$) by calendar day for the Fish Creek gaging station based on the entire period of record (16 July 2008 to 30 September 2013).

| Day | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 31 | 25 | 20 | 45 | 182 | 65 | 32 | 36 | 48 | 79 | 43 | 31 |
| 2 | 30 | 25 | 19 | 48 | 176 | 63 | 33 | 35 | 49 | 75 | 42 | 31 |
| 3 | 31 | 25 | 19 | 50 | 165 | 62 | 32 | 35 | 51 | 73 | 42 | 30 |
| 4 | 30 | 25 | 19 | 51 | 157 | 63 | 33 | 34 | 57 | 73 | 42 | 31 |
| 5 | 30 | 24 | 19 | 56 | 151 | 61 | 33 | 38 | 67 | 74 | 42 | 31 |
| 6 | 30 | 24 | 19 | 60 | 145 | 59 | 31 | 39 | 65 | 101 | 43 | 31 |
| 7 | 30 | 23 | 20 | 65 | 139 | 56 | 30 | 40 | 65 | 115 | 41 | 30 |
| 8 | 30 | 23 | 20 | 68 | 133 | 54 | 29 | 39 | 65 | 112 | 39 | 29 |
| 9 | 29 | 23 | 19 | 74 | 129 | 52 | 28 | 41 | 65 | 106 | 38 | 28 |
| 10 | 29 | 23 | 19 | 75 | 125 | 50 | 27 | 42 | 63 | 100 | 38 | 28 |
| 11 | 30 | 22 | 18 | 80 | 120 | 49 | 27 | 41 | 74 | 94 | 37 | 27 |
| 12 | 30 | 23 | 17 | 84 | 114 | 50 | 27 | 40 | 99 | 92 | 37 | 28 |
| 13 | 30 | 22 | 16 | 91 | 111 | 52 | 27 | 39 | 87 | 86 | 38 | 28 |
| 14 | 30 | 21 | 16 | 95 | 105 | 51 | 26 | 39 | 77 | 84 | 37 | 28 |
| 15 | 30 | 21 | 17 | 110 | 100 | 49 | 25 | 40 | 72 | 86 | 35 | 30 |
| 16 | 31 | 21 | 17 | 109 | 96 | 49 | 24 | 40 | 75 | 80 | 34 | 29 |
| 17 | 31 | 21 | 19 | 108 | 99 | 47 | 25 | 40 | 86 | 78 | 34 | 28 |
| 18 | 31 | 20 | 20 | 122 | 107 | 45 | 30 | 40 | 87 | 81 | 33 | 26 |
| 19 | 31 | 20 | 22 | 138 | 102 | 44 | 30 | 41 | 94 | 74 | 33 | 26 |
| 20 | 31 | 20 | 26 | 161 | 95 | 43 | 29 | 41 | 127 | 65 | 33 | 26 |
| 21 | 31 | 20 | 30 | 166 | 90 | 40 | 31 | 41 | 160 | 63 | 34 | 26 |
| 22 | 30 | 20 | 33 | 161 | 86 | 38 | 32 | 43 | 147 | 59 | 33 | 25 |
| 23 | 30 | 20 | 38 | 198 | 82 | 37 | 33 | 47 | 126 | 57 | 32 | 24 |
| 24 | 30 | 19 | 39 | 197 | 80 | 34 | 36 | 50 | 117 | 57 | 33 | 24 |
| 25 | 29 | 20 | 40 | 202 | 77 | 34 | 37 | 47 | 115 | 55 | 33 | 24 |
| 26 | 27 | 20 | 37 | 222 | 74 | 35 | 39 | 44 | 118 | 54 | 32 | 23 |
| 27 | 24 | 20 | 36 | 247 | 73 | 34 | 46 | 45 | 113 | 53 | 33 | 23 |
| 28 | 24 | 20 | 36 | 220 | 72 | 36 | 45 | 45 | 106 | 51 | 32 | 23 |
| 29 | 24 | - | 39 | 202 | 72 | 34 | 44 | 46 | 104 | 49 | 32 | 23 |
| 30 | 25 | - | 41 | 189 | 69 | 32 | 41 | 45 | 101 | 47 | 31 | 23 |
| 31 | 25 | - | 42 | - | 67 | - | 38 | 46 | - | 43 | - | 22 |

Table 3.–Monthly exceedance and monthly mean flows ($ft^3/s$) for Fish Creek gaging station based on complete months of record (1 August 2008 to 30 September 2013).

| % Time exceeded | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 86 | 55 | 115 | 497 | 350 | 141 | 52 | 104 | 652 | 428 | 95 | 62 |
| 5 | 83 | 50 | 91 | 411 | 302 | 118 | 50 | 76 | 325 | 268 | 85 | 57 |
| 10 | 76 | 36 | 30 | 312 | 249 | 81 | 45 | 61 | 210 | 231 | 81 | 55 |
| 15 | 72 | 30 | 24 | 259 | 212 | 67 | 42 | 56 | 185 | 145 | 80 | 42 |
| 20 | 45 | 25 | 24 | 210 | 176 | 61 | 39 | 53 | 161 | 98 | 55 | 37 |
| 25 | 33 | 23 | 23 | 148 | 152 | 58 | 36 | 50 | 89 | 76 | 47 | 28 |
| 30 | 25 | 22 | 22 | 130 | 125 | 53 | 34 | 47 | 72 | 65 | 43 | 25 |
| 35 | 19 | 20 | 21 | 115 | 100 | 50 | 33 | 46 | 57 | 58 | 36 | 24 |
| 40 | 18 | 19 | 20 | 98 | 85 | 47 | 31 | 44 | 52 | 49 | 31 | 23 |
| 45 | 18 | 18 | 20 | 82 | 72 | 40 | 28 | 43 | 50 | 39 | 25 | 22 |
| 50 | 17 | 18 | 20 | 72 | 67 | 37 | 26 | 40 | 45 | 34 | 24 | 21 |
| 55 | 17 | 17 | 19 | 65 | 63 | 34 | 25 | 38 | 41 | 32 | 21 | 21 |
| 60 | 17 | 17 | 19 | 55 | 60 | 33 | 23 | 37 | 36 | 30 | 20 | 20 |
| 65 | 17 | 17 | 19 | 50 | 58 | 32 | 22 | 34 | 33 | 28 | 20 | 19 |
| 70 | 16 | 17 | 18 | 45 | 55 | 30 | 20 | 31 | 30 | 27 | 19 | 18 |
| 75 | 16 | 16 | 18 | 43 | 51 | 29 | 18 | 28 | 25 | 26 | 19 | 18 |
| 80 | 16 | 16 | 18 | 40 | 47 | 26 | 16 | 26 | 23 | 23 | 18 | 18 |
| 85 | 14 | 15 | 17 | 38 | 44 | 25 | 15 | 24 | 21 | 22 | 18 | 18 |
| 90 | 13 | 14 | 15 | 35 | 40 | 23 | 13 | 20 | 19 | 22 | 17 | 17 |
| 95 | 12 | 11 | 13 | 28 | 36 | 21 | 12 | 18 | 15 | 21 | 13 | 17 |
| 100 | 9 | 8.5 | 6.6 | 22 | 28 | 15 | 10 | 12 | 11 | 14 | 12 | 14 |
| Mean | 29 | 22 | 26 | 123 | 109 | 47 | 28 | 41 | 89 | 75 | 36 | 27 |

Table 4.–Mean annual flows for the Fish and Meadow Creek gaging and discharge stations based on complete water years of record (1 October 2008 to 30 September 2013).

| | Fish Creek | | Meadow Creek | |
|---|---|---|---|---|
| Water year | Gaging | Discharge | Gaging | Discharge |
| 2009 | 41 | 27 | 17 | 7.3 |
| 2010 | 30 | 21 | 13 | 6.1 |
| 2011 | 34 | 24 | 13 | 6.0 |
| 2012 | 66 | 41 | 26 | 10 |
| 2013 | 104 | 62 | 45 | 17 |
| Overall mean | 55 | 35 | 22 | 9.3 |

Table 5.–Summary of instantaneous discharge measurements at the Fish Creek discharge station.

| Date | Start time | End time | Discharge ($ft^3/s$) | Quality rating |
|---|---|---|---|---|
| 7/25/2008 | 1409 | 1509 | 43.6 | Fair |
| 8/1/2008 | 1501 | 1536 | 50.9 | Fair |
| 8/6/2008 | 1210 | 1242 | 52.3 | Fair |
| 8/21/2008 | 1403 | 1436 | 31.7 | Fair |
| 9/11/2008 | 0943 | 1017 | 27.1 | Fair |
| 9/29/2008 | 1036 | 1143 | 38.5 | Fair |
| 1/29/2009 | 1103 | 1138 | 29.9 | Fair |
| 3/10/2009 | 1045 | 1130 | 23.5 | Fair |
| 4/10/2009 | 1305 | 1335 | 18.9 | Fair |
| 5/15/2009 | 0855 | 0922 | 49.7 | Fair |
| 6/1/2009 | 1330 | 1406 | 41.8 | Fair |
| 6/12/2009 | 1251 | 1324 | 23.1 | Fair |
| 6/22/2009 | 0928 | 1003 | 24.4 | Fair |
| 7/17/2009 | 1241 | 1337 | 13.6 | Fair |
| 7/31/2009 | 0854 | 0930 | 16.2 | Fair |
| 8/13/2009 | 1259 | 1338 | 11.9 | Fair |
| 8/24/2009 | 1347 | 1418 | 19.4 | Fair |
| 9/14/2009 | 1341 | 1418 | 17.0 | Fair |
| 10/13/2009 | 1206 | 1236 | 23.5 | Fair |
| 12/8/2009 | 1248 | 1317 | 15.6 | Fair |
| 1/7/2010 | 1300 | 1339 | 12.5 | Fair |
| 2/3/2010 | 1241 | 1311 | 9.7 | Fair |
| 3/4/2010 | 1157 | 1233 | 12.0 | Fair |
| 4/23/2010 | 0836 | 0904 | 31.5 | Fair |
| 6/2/2010 | 0952 | 1035 | 16.0 | Fair |
| 6/10/2010 | 1039 | 1102 | 13.7 | Fair |
| 6/21/2010 | 0851 | 0916 | 13.5 | Fair |
| 7/1/2010 | 1105 | 1145 | 14.7 | Fair |
| 7/19/2010 | 0848 | 0915 | 13.9 | Fair |
| 7/30/2010 | 1416 | 1442 | 26.3 | Fair |
| 8/23/2010 | 0912 | 0938 | 25.0 | Fair |
| 9/14/2010 | 0932 | 0947 | 26.5 | Fair |
| 10/06/2010 | 1020 | 1041 | 17.1 | Poor |
| 10/21/2010 | 1142 | 1218 | 26.1 | Fair |
| 2/11/2011 | 1036 | 1057 | 9.2 | Fair |
| 3/22/2011 | 1331 | 1352 | 5.1 | Fair |

-continued-

Table 5.–Page 2 of 2.

| Date | Start time | End time | Discharge ($ft^3/s$) | Quality rating |
|---|---|---|---|---|
| 4/26/2011 | 1148 | 1207 | 36.0 | Fair |
| 5/20/2011 | 1024 | 1055 | 29.7 | Fair |
| 6/4/2011 | 0956 | 1045 | 17.6 | Fair |
| 6/22/2011 | 1316 | 1424 | 14.7 | Fair |
| 7/5/2011 | 1411 | 1455 | 9.3 | Fair |
| 7/19/2011 | 1328 | 1414 | 11.7 | Fair |
| 8/8/2011 | 1714 | 1757 | 23.7 | Fair |
| 8/24/2011 | 1437 | 1538 | 29.5 | Fair |
| 9/6/2011 | 1551 | 1630 | 24.7 | Fair |
| 9/23/2011 | 1420 | 1454 | 12.3 | Fair |
| 9/27/2011 | 1450 | 1507 | 11.7 | Good |
| 10/24/2011 | 1400 | 1436 | 18.3 | Fair |
| 11/17/2011 | 1315 | 1401 | 22.2 | Fair |
| 12/13/2011 | 1321 | 1401 | 29.9 | Fair |
| 12/19/2011 | 1219 | 1256 | 25.8 | Fair |
| 1/29/2012 | 1137 | 1230 | 15.0 | Poor |
| 2/16/2012 | 1321 | 1359 | 13.7 | Poor |
| 3/22/2012 | 1153 | 1227 | 11.0 | Poor |
| 4/16/2012 | 1303 | 1339 | 14.6 | Fair |
| 5/1/2012 | 1022 | 1045 | 116.0 | Good |
| 5/8/2012 | 1605 | 1632 | 78.7 | Fair |
| 5/22/2012 | 1508 | 1538 | 45.3 | Poor |
| 6/7/2012 | 1438 | 1509 | 42.3 | Fair |
| 6/21/2012 | 1410 | 1455 | 43.3 | Fair |
| 6/28/2012 | 1458 | 1543 | 40.4 | Fair |
| 7/14/2012 | 1422 | 1447 | 24.8 | Fair |
| 8/11/2012 | 1934 | 2026 | 23.5 | Fair |
| 8/23/2012 | 14.41 | 1543 | 27.9 | Fair |
| 9/6/2012 | 1208 | 1254 | 35.6 | Poor |
| 12/13/2012 | 1134 | 1218 | 42.1 | Poor |
| 2/12/2013 | 1122 | 1147 | 42.3 | Fair |
| 3/8/2013 | 1253 | 1327 | 30.2 | Fair |
| 6/24/2013 | 0912 | 0944 | 40.2 | Poor |
| 6/29/2013 | 2105 | 2137 | 40.6 | Poor |
| 7/13/2013 | 1016 | 1047 | 37.3 | Poor |
| 7/26/2013 | 1256 | 1331 | 44.8 | Poor |
| 8/9/2013 | 1301 | 1337 | 45.3 | Poor |
| 8/26/2013 | 1202 | 1238 | 43.3 | Poor |

Table 6.–Mean of daily mean flows ($ft^3/s$) by calendar day for the Fish Creek discharge station based on the entire period of record (16 July 2008 to 30 September 2013).

| Day | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 22 | 19 | 16 | 30 | 105 | 41 | 23 | 25 | 31 | 48 | 28 | 22 |
| 2 | 22 | 19 | 16 | 31 | 101 | 40 | 23 | 24 | 32 | 46 | 28 | 22 |
| 3 | 22 | 19 | 15 | 32 | 96 | 39 | 23 | 24 | 33 | 45 | 28 | 22 |
| 4 | 22 | 19 | 15 | 33 | 91 | 40 | 23 | 24 | 36 | 45 | 28 | 22 |
| 5 | 22 | 18 | 16 | 36 | 88 | 39 | 23 | 26 | 42 | 46 | 28 | 22 |
| 6 | 22 | 18 | 16 | 38 | 84 | 37 | 22 | 26 | 41 | 60 | 28 | 22 |
| 7 | 22 | 18 | 16 | 41 | 81 | 36 | 22 | 27 | 41 | 68 | 28 | 22 |
| 8 | 21 | 18 | 16 | 42 | 78 | 34 | 21 | 26 | 41 | 67 | 26 | 21 |
| 9 | 21 | 18 | 15 | 46 | 76 | 34 | 21 | 28 | 41 | 63 | 26 | 21 |
| 10 | 21 | 17 | 15 | 46 | 74 | 32 | 20 | 28 | 40 | 60 | 26 | 20 |
| 11 | 21 | 17 | 15 | 49 | 71 | 32 | 20 | 27 | 46 | 57 | 25 | 20 |
| 12 | 21 | 18 | 14 | 51 | 68 | 32 | 20 | 27 | 59 | 55 | 25 | 20 |
| 13 | 22 | 17 | 14 | 55 | 66 | 34 | 20 | 27 | 53 | 52 | 26 | 20 |
| 14 | 22 | 17 | 14 | 57 | 63 | 33 | 19 | 26 | 48 | 51 | 25 | 21 |
| 15 | 22 | 17 | 14 | 66 | 60 | 32 | 19 | 27 | 44 | 52 | 24 | 22 |
| 16 | 22 | 17 | 14 | 65 | 58 | 32 | 18 | 27 | 46 | 49 | 24 | 21 |
| 17 | 22 | 17 | 15 | 64 | 59 | 31 | 19 | 27 | 52 | 48 | 24 | 21 |
| 18 | 22 | 16 | 16 | 72 | 64 | 30 | 22 | 27 | 53 | 49 | 23 | 19 |
| 19 | 22 | 16 | 17 | 81 | 61 | 29 | 22 | 27 | 57 | 45 | 23 | 19 |
| 20 | 22 | 16 | 19 | 93 | 57 | 29 | 21 | 28 | 74 | 41 | 23 | 19 |
| 21 | 22 | 16 | 21 | 96 | 54 | 27 | 22 | 28 | 93 | 39 | 24 | 19 |
| 22 | 22 | 16 | 23 | 93 | 52 | 26 | 23 | 29 | 86 | 37 | 23 | 19 |
| 23 | 22 | 16 | 26 | 114 | 50 | 25 | 23 | 31 | 74 | 36 | 23 | 18 |
| 24 | 21 | 16 | 27 | 113 | 49 | 24 | 25 | 32 | 69 | 36 | 23 | 18 |
| 25 | 21 | 16 | 27 | 116 | 48 | 24 | 25 | 31 | 68 | 35 | 23 | 18 |
| 26 | 20 | 16 | 25 | 127 | 45 | 24 | 26 | 29 | 70 | 34 | 23 | 18 |
| 27 | 18 | 16 | 25 | 140 | 45 | 24 | 30 | 30 | 67 | 34 | 23 | 18 |
| 28 | 18 | 16 | 25 | 126 | 44 | 25 | 30 | 30 | 63 | 33 | 23 | 18 |
| 29 | 18 | - | 26 | 116 | 44 | 24 | 29 | 30 | 62 | 32 | 22 | 18 |
| 30 | 19 | - | 28 | 109 | 43 | 23 | 27 | 30 | 60 | 31 | 22 | 18 |
| 31 | 19 | - | 28 | - | 42 | - | 26 | 30 | - | 29 | - | 17 |

Table 7.–Monthly exceedance and monthly mean flows ($ft^3/s$) for the Fish Creek discharge station, based on complete months of record (1 August 2008 to 30 September 2013).

| % Time exceeded | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 52 | 35 | 68 | 277 | 197 | 82 | 33 | 62 | 362 | 240 | 57 | 39 |
| 5 | 51 | 33 | 55 | 230 | 171 | 69 | 32 | 47 | 183 | 152 | 52 | 36 |
| 10 | 47 | 25 | 22 | 176 | 141 | 50 | 30 | 39 | 120 | 132 | 49 | 35 |
| 15 | 45 | 22 | 18 | 147 | 121 | 42 | 28 | 36 | 106 | 85 | 49 | 28 |
| 20 | 29 | 19 | 18 | 120 | 102 | 38 | 27 | 34 | 93 | 59 | 35 | 25 |
| 25 | 23 | 18 | 18 | 86 | 89 | 37 | 25 | 33 | 54 | 47 | 31 | 20 |
| 30 | 19 | 17 | 17 | 76 | 74 | 34 | 24 | 31 | 45 | 41 | 29 | 19 |
| 35 | 16 | 16 | 17 | 68 | 60 | 32 | 23 | 30 | 37 | 37 | 25 | 18 |
| 40 | 15 | 16 | 16 | 59 | 52 | 31 | 22 | 29 | 34 | 32 | 22 | 18 |
| 45 | 15 | 15 | 16 | 50 | 45 | 27 | 20 | 28 | 32 | 26 | 19 | 17 |
| 50 | 14 | 15 | 16 | 44 | 42 | 26 | 19 | 27 | 30 | 24 | 18 | 17 |
| 55 | 14 | 14 | 16 | 41 | 40 | 24 | 19 | 26 | 28 | 23 | 17 | 17 |
| 60 | 14 | 14 | 16 | 35 | 38 | 23 | 18 | 25 | 25 | 22 | 16 | 16 |
| 65 | 14 | 14 | 16 | 33 | 37 | 23 | 17 | 24 | 23 | 20 | 16 | 16 |
| 70 | 14 | 14 | 15 | 30 | 35 | 22 | 16 | 22 | 21 | 20 | 16 | 15 |
| 75 | 14 | 14 | 15 | 29 | 33 | 21 | 15 | 21 | 19 | 20 | 16 | 15 |
| 80 | 14 | 14 | 15 | 27 | 31 | 19 | 14 | 19 | 18 | 18 | 15 | 15 |
| 85 | 13 | 13 | 14 | 26 | 29 | 19 | 13 | 18 | 17 | 17 | 15 | 15 |
| 90 | 12 | 13 | 13 | 24 | 27 | 18 | 12 | 16 | 16 | 17 | 14 | 14 |
| 95 | 12 | 11 | 12 | 20 | 25 | 17 | 12 | 15 | 14 | 16 | 12 | 14 |
| 100 | 10 | 9.7 | 8.7 | 17 | 21 | 14 | 11 | 12 | 11 | 13 | 12 | 13 |
| Mean | 21 | 17 | 19 | 73 | 65 | 31 | 20 | 28 | 54 | 46 | 25 | 20 |

Table 8.–Summary of instantaneous discharge measurements taken at the Meadow Creek gaging station.

| Date | Start time | End time | Discharge ($ft^3/s$) | Staff gage (ft) | Quality rating |
|---|---|---|---|---|---|
| 7/16/08 | 1212 | 1310 | 25.8 | 1.36 | Poor |
| 07/24/08 | 1623 | 1709 | 31.9 | 1.88 | Fair |
| 07/31/08 | 1218 | 1255 | 30.9 | 1.83 | Fair |
| 08/19/08 | 0923 | 1042 | 20.5 | 1.54 | Fair |
| 09/17/08 | 1109 | 1146 | 27.6 | 1.80 | Fair |
| 10/23/08 | 0928 | 1005 | 17.0 | 2.08 | Fair |
| 01/29/09 | 1432 | 1453 | 13.9 | ice | Poor |
| 04/10/09 | 1022 | 1041 | 16.7 | ice | Poor |
| 04/24/09 | 1006 | 1130 | 49.6 | 2.11 | Fair |
| 05/26/09 | 1122 | 1225 | 23.3 | 1.59 | Poor |
| 06/11/09 | 1055 | 1126 | 27.8 | 1.65 | Fair |
| 06/23/09 | 0921 | 1018 | 19.1 | 1.50 | Fair |
| 07/15/09 | 0904 | 0947 | 13.2 | 1.36 | Fair |
| 07/27/09 | 10.21 | 10.51 | 11.9 | 1.34 | Fair |
| 08/11/09 | 1115 | 1155 | 14.5 | 1.44 | Fair |
| 08/24/09 | 1006 | 1035 | 15.0 | 1.43 | Fair |
| 09/11/09 | 0936 | 1006 | 12.3 | 1.38 | Fair |
| 10/14/09 | 1023 | 1059 | 18.1 | 1.58 | Fair |
| 01/28/10 | 1142 | 1205 | 3.5 | ice | Poor |
| 04/23/10 | 0944 | 1003 | 28.3 | 2.08 | Fair |
| 05/24/10 | 0848 | 0916 | 18.2 | 1.51 | Fair |
| 06/13/10 | 1007 | 1034 | 11.8 | 1.39 | Fair |
| 07/05/10 | 1238 | 1310 | 15.0 | 1.44 | Fair |
| 07/19/10 | 0942 | 1011 | 11.6 | 1.38 | Fair |
| 07/30/10 | 1520 | 1544 | 20.2 | 1.54 | Fair |
| 08/09/10 | 0853 | 0923 | 20.0 | 1.59 | Fair |
| 08/25/10 | 1543 | 1603 | 18.6 | 1.56 | Fair |
| 09/13/10 | 1007 | 1034 | 20.0 | 1.64 | Fair |
| 10/01/10 | 1626 | 1650 | 16.5 | 1.63 | Fair |
| 01/06/11 | 1317 | 1327 | 7.3 | ice | Poor |
| 03/23/11 | 1047 | 1108 | 2.5 | ice | Poor |
| 04/26/11 | 1017 | 1043 | 31.3 | 1.93 | Fair |
| 05/13/11 | 1151 | 1233 | 22.6 | 1.71 | Fair |
| 06/15/11 | 1258 | 1337 | 16.9 | 1.56 | Fair |
| 06/30/11 | 1105 | 1150 | 11.8 | 1.46 | Fair |
| 07/13/11 | 1053 | 1128 | 11.6 | 1.44 | Fair |

-continued-

Table 8.–Page 2 of 2.

| Date | Start time | End time | Discharge ($ft^3/s$) | Staff gage (ft) | Quality rating |
|---|---|---|---|---|---|
| 07/27/11 | 1059 | 1127 | 10.7 | 1.42 | Fair |
| 08/10/11 | 1021 | 1059 | 28.4 | 1.85 | Fair |
| 09/01/11 | 1212 | 1246 | 19.5 | 1.75 | Fair |
| 09/15/11 | 1151 | 1217 | 14.5 | 1.55 | Fair |
| 09/29/11 | 1402 | 1429 | 12.8 | 1.51 | Fair |
| 12/9/2011 | 1430 | 1500 | 14.0 | ice | Poor |
| 02/03/12 | 1538 | 1604 | 4.9 | ice | Poor |
| 04/25/12 | 1510 | 1543 | 91.5 | 2.84 | Fair |
| 04/27/12 | 1100 | 1145 | 80.8 | 2.70 | Fair |
| 05/11/12 | 1500 | 1525 | 48.0 | 2.12 | Fair |
| 05/15/12 | 1241 | 1312 | 39.7 | 2.10 | Fair |
| 05/30/12 | 1115 | 1155 | 32.2 | 1.75 | Fair |
| 06/11/12 | 1005 | 1031 | 29.4 | 1.86 | Fair |
| 06/25/12 | 1132 | 1216 | 29.4 | 1.85 | Fair |
| 08/03/12 | 1226 | 1306 | 23.1 | 1.84 | Fair |
| 08/16/12 | 1042 | 1120 | 17.4 | 1.68 | Fair |
| 08/31/12 | 1613 | 1658 | 25.0 | 2.10 | Fair |
| 09/14/12 | 1059 | 1139 | 27.9 | 2.04 | Fair |
| 12/12/12 | 1158 | 1221 | 23.9 | ice | Poor |
| 02/14/13 | 1018 | 1040 | 26.2 | ice | Poor |
| 03/08/13 | 1114 | 1147 | 22.5 | ice | Poor |
| 05/17/13 | 928 | 1005 | 87.4 | 2.93 | Poor |
| 05/24/13 | 1353 | 1446 | 79.2 | 2.87 | Fair |
| 07/02/13 | 1815 | 1850 | 37.4 | 2.13 | Poor |
| 07/05/13 | 1031 | 1108 | 33.5 | 2.11 | Fair |
| 07/13/13 | 1129 | 1207 | 29.4 | 2.03 | Fair |
| 07/26/13 | 1043 | 1129 | 29.5 | 2.04 | Fair |
| 08/02/13 | 0918 | 0949 | 20.3 | 1.85 | Fair |
| 08/09/13 | 1035 | 1135 | 29.5 | 2.04 | Fair |
| 08/23/13 | 1053 | 1119 | 47.1 | 2.50 | Fair |
| 08/26/13 | 1105 | 1130 | 35.2 | 2.1 | Fair |
| 09/09/13 | 1031 | 1201 | 35.4 | 2.10 | Fair |
| 09/19/13 | 1121 | 1146 | 80.9 | 3.10 | Poor |
| 09/26/13 | 1009 | 1035 | 87.5 | 3.21 | Poor |

Table 9.–Mean of daily mean flows ($ft^3/s$) by calendar day for the Meadow Creek gaging station based on entire period of record (16 July 2008 to 30 September 2013).

| Day | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 8.7 | 7.5 | 6.3 | 8.4 | 53 | 33 | 21 | 20 | 22 | 45 | 18 | 11 |
| 2 | 8.6 | 7.1 | 6.8 | 8.8 | 51 | 32 | 21 | 19 | 22 | 42 | 18 | 10 |
| 3 | 8.7 | 6.9 | 7.1 | 9.4 | 50 | 34 | 20 | 19 | 23 | 40 | 17 | 9.7 |
| 4 | 7.6 | 6.7 | 7.5 | 10 | 51 | 33 | 20 | 19 | 24 | 40 | 17 | 9.9 |
| 5 | 7.3 | 6.7 | 7.6 | 11 | 53 | 33 | 20 | 20 | 27 | 41 | 16 | 9.8 |
| 6 | 7.5 | 6.7 | 7.6 | 12 | 53 | 34 | 19 | 20 | 27 | 45 | 17 | 10 |
| 7 | 7.3 | 7.1 | 7.9 | 13 | 52 | 32 | 19 | 20 | 27 | 51 | 17 | 10 |
| 8 | 6.5 | 7.0 | 8.1 | 14 | 51 | 31 | 19 | 20 | 27 | 52 | 17 | 10 |
| 9 | 6.6 | 7.6 | 8.1 | 15 | 47 | 30 | 19 | 21 | 27 | 51 | 16 | 11 |
| 10 | 6.4 | 7.9 | 8.3 | 16 | 46 | 30 | 18 | 22 | 26 | 49 | 16 | 11 |
| 11 | 6.6 | 8.5 | 7.6 | 17 | 46 | 29 | 18 | 22 | 27 | 47 | 17 | 12 |
| 12 | 6.8 | 8.1 | 7.6 | 19 | 48 | 29 | 18 | 22 | 30 | 45 | 17 | 12 |
| 13 | 6.2 | 8.6 | 7.7 | 21 | 45 | 30 | 18 | 22 | 31 | 43 | 17 | 12 |
| 14 | 6.7 | 9.4 | 7.3 | 23 | 43 | 29 | 18 | 21 | 30 | 41 | 17 | 12 |
| 15 | 6.2 | 9.3 | 7.3 | 25 | 41 | 29 | 18 | 20 | 29 | 40 | 16 | 12 |
| 16 | 6.9 | 9.1 | 7.5 | 28 | 39 | 28 | 18 | 20 | 31 | 39 | 15 | 12 |
| 17 | 5.9 | 8.6 | 6.8 | 31 | 40 | 27 | 20 | 20 | 34 | 37 | 15 | 12 |
| 18 | 6.3 | 8.7 | 6.8 | 36 | 42 | 26 | 21 | 21 | 36 | 35 | 15 | 12 |
| 19 | 6.6 | 8.2 | 6.4 | 42 | 40 | 25 | 21 | 21 | 38 | 35 | 14 | 12 |
| 20 | 6.7 | 7.8 | 6.4 | 47 | 39 | 25 | 21 | 22 | 44 | 34 | 13 | 12 |
| 21 | 7.5 | 7.4 | 6.0 | 55 | 38 | 23 | 22 | 22 | 55 | 32 | 13 | 12 |
| 22 | 7.7 | 7.3 | 6.1 | 56 | 37 | 22 | 21 | 23 | 62 | 31 | 12 | 11 |
| 23 | 7.6 | 7.1 | 5.9 | 62 | 36 | 22 | 21 | 24 | 63 | 30 | 11 | 11 |
| 24 | 8.1 | 6.7 | 6.2 | 72 | 35 | 21 | 21 | 25 | 61 | 27 | 11 | 11 |
| 25 | 7.7 | 6.7 | 6.4 | 81 | 34 | 21 | 22 | 23 | 60 | 25 | 9.9 | 11 |
| 26 | 7.0 | 6.7 | 6.4 | 83 | 32 | 23 | 23 | 22 | 59 | 24 | 10 | 10 |
| 27 | 6.7 | 6.0 | 6.6 | 73 | 32 | 22 | 24 | 21 | 56 | 23 | 10 | 10 |
| 28 | 6.5 | 5.6 | 6.8 | 71 | 32 | 22 | 23 | 22 | 53 | 22 | 10 | 10 |
| 29 | 6.4 | - | 7.4 | 63 | 32 | 21 | 22 | 22 | 51 | 20 | 10 | 9.6 |
| 30 | 7.0 | - | 7.6 | 56 | 33 | 21 | 21 | 22 | 50 | 19 | 11 | 9.6 |
| 31 | 6.9 | - | 8.0 | - | 33 | - | 20 | 22 | - | 18 | - | 9.4 |

Table 10.–Monthly exceedance and monthly mean flows ($ft^3/s$) for Meadow Creek gaging station, based on complete months of record (1 August 2008 to 30 September 2013).

| % Time exceeded | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 22 | 26 | 23 | 225 | 125 | 83 | 37 | 49 | 244 | 183 | 38 | 26 |
| 5 | 16 | 21 | 20 | 115 | 105 | 67 | 32 | 31 | 161 | 146 | 36 | 25 |
| 10 | 13 | 17 | 15 | 78 | 96 | 54 | 30 | 28 | 77 | 117 | 32 | 23 |
| 15 | 12 | 12 | 12 | 58 | 80 | 38 | 29 | 26 | 63 | 75 | 21 | 15 |
| 20 | 10 | 11 | 9.5 | 49 | 65 | 33 | 26 | 25 | 54 | 32 | 16 | 14 |
| 25 | 9.0 | 11 | 8.0 | 44 | 51 | 32 | 25 | 24 | 37 | 29 | 14 | 13 |
| 30 | 8.0 | 9.6 | 7.4 | 39 | 41 | 31 | 25 | 23 | 31 | 27 | 13 | 12 |
| 35 | 6.2 | 8.6 | 7.4 | 33 | 38 | 28 | 24 | 23 | 29 | 21 | 13 | 10 |
| 40 | 6.0 | 6.0 | 6.7 | 30 | 35 | 26 | 23 | 22 | 27 | 18 | 13 | 9.9 |
| 45 | 5.2 | 6.0 | 5.8 | 28 | 34 | 23 | 19 | 21 | 25 | 17 | 12 | 9.0 |
| 50 | 5.0 | 5.0 | 5.0 | 25 | 32 | 22 | 16 | 21 | 22 | 17 | 12 | 9.0 |
| 55 | 5.0 | 5.0 | 5.0 | 22 | 28 | 19 | 14 | 20 | 21 | 16 | 12 | 8.0 |
| 60 | 5.0 | 4.5 | 4.6 | 19 | 26 | 19 | 13 | 20 | 19 | 16 | 11 | 8.0 |
| 65 | 4.8 | 4.0 | 4.1 | 16 | 25 | 17 | 13 | 20 | 17 | 15 | 11 | 7.4 |
| 70 | 4.5 | 3.5 | 4.0 | 15 | 24 | 16 | 12 | 19 | 15 | 15 | 10 | 7.0 |
| 75 | 4.5 | 3.0 | 4.0 | 13 | 23 | 16 | 12 | 18 | 15 | 15 | 10 | 6.8 |
| 80 | 4.0 | 2.9 | 3.9 | 12 | 21 | 14 | 11 | 17 | 14 | 14 | 9.0 | 6.6 |
| 85 | 4.0 | 2.6 | 2.5 | 9.8 | 19 | 14 | 11 | 15 | 14 | 14 | 7.4 | 6.2 |
| 90 | 3.6 | 2.5 | 2.5 | 7.8 | 18 | 14 | 11 | 14 | 13 | 13 | 6.9 | 6.0 |
| 95 | 3.0 | 2.0 | 2.0 | 6.8 | 16 | 13 | 10 | 13 | 13 | 13 | 6.2 | 5.6 |
| 100 | 2.0 | 1.5 | 2.0 | 6.0 | 14 | 12 | 9.7 | 10 | 13 | 12 | 6.0 | 3.0 |
| Mean | 7.1 | 7.5 | 7.1 | 36 | 42 | 27 | 19 | 21 | 38 | 36 | 14 | 11 |

Table 11.–Summary of instantaneous discharge measurements taken at the Meadow Creek discharge station.

| Date | Start time | End time | Discharge ($ft^3/s$) | Quality rating |
|---|---|---|---|---|
| 7/24/2008 | 1422 | 1509 | 17.1 | Fair |
| 7/31/2008 | 1456 | 1537 | 15.7 | Fair |
| 8/19/2008 | 1429 | 1504 | 9.1 | Poor |
| 9/17/2008 | 1320 | 1358 | 14.3 | Fair |
| 10/23/2008 | 1131 | 1200 | 11.5 | Fair |
| 3/10/2009 | 1145 | 1245 | 5.7 | Poor |
| 4/10/2009 | 1231 | 1247 | 8.3 | Fair |
| 4/24/2009 | 1240 | 1319 | 14.9 | Fair |
| 5/26/2009 | 1323 | 1358 | 7.9 | Fair |
| 6/11/2009 | 1205 | 1233 | 8.1 | Fair |
| 6/23/2009 | 1109 | 1146 | 7.6 | Fair |
| 7/15/2009 | 1033 | 1111 | 5.1 | Fair |
| 7/27/2009 | 0857 | 0927 | 5.4 | Fair |
| 8/11/2009 | 1242 | 1309 | 6.0 | Fair |
| 8/24/2009 | 1129 | 1206 | 7.6 | Fair |
| 9/11/2009 | 1048 | 1115 | 5.8 | Fair |
| 10/14/2009 | 1129 | 1202 | 7.7 | Fair |
| 1/28/2010 | 1345 | 1400 | 3.5 | Poor |
| 3/30/2010 | 1104 | 1137 | 4.0 | Poor |
| 4/23/2010 | 1234 | 1226 | 7.8 | Fair |
| 5/24/2010 | 1017 | 1050 | 4.7 | Fair |
| 6/13/2010 | 1112 | 1140 | 4.6 | Fair |
| 7/5/2010 | 1142 | 1216 | 4.7 | Fair |
| 7/19/2010 | 1054 | 1116 | 4.1 | Fair |
| 7/30/2010 | 1612 | 1643 | 6.9 | Fair |
| 8/9/2010 | 0947 | 1015 | 7.0 | Fair |
| 8/25/2010 | 1440 | 1504 | 7.6 | Fair |
| 9/13/2010 | 0847 | 0916 | 7.6 | Fair |
| 10/1/2010 | 1718 | 1740 | 7.5 | Poor |
| 11/24/2010 | 1305 | 1320 | 7.1 | Fair |
| 1/6/2011 | 1041 | 1056 | 3.4 | Poor |
| 3/22/2011 | 1237 | 1249 | 2.6 | Poor |
| 4/26/2011 | 1251 | 1310 | 10.6 | Good |
| 5/13/2011 | 1318 | 1354 | 7.4 | Fair |
| 6/15/2011 | 1421 | 1517 | 5.3 | Fair |

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Table 11.–Page 2 of 2.

| Date | Start time | End time | Discharge ($ft^3/s$) | Quality rating |
|---|---|---|---|---|
| 6/30/2011 | 1401 | 1440 | 5.0 | Fair |
| 7/13/2011 | 1255 | 1324 | 5.3 | Fair |
| 7/27/2011 | 1314 | 1345 | 5.0 | Fair |
| 8/10/2011 | 1331 | 1415 | 11.6 | Fair |
| 9/1/2011 | 1404 | 1445 | 9.0 | Fair |
| 9/15/2011 | 1256 | 1321 | 6.9 | Fair |
| 9/29/2011 | 1507 | 1531 | 6.0 | Fair |
| 10/31/2011 | 1338 | 1435 | 7.6 | Fair |
| 12/13/2011 | 1425 | 1444 | 8.1 | Fair |
| 2/16/2012 | 1422 | 1506 | 5.7 | Fair |
| 3/29/2012 | 1152 | 1219 | 4.1 | Fair |
| 4/25/2012 | 1636 | 1708 | 22.0 | Fair |
| 4/27/2012 | 0917 | 0949 | 22.8 | Fair |
| 5/15/2012 | 1446 | 1517 | 14.0 | Fair |
| 5/30/2012 | 1433 | 1501 | 11.5 | Fair |
| 6/25/2012 | 1338 | 1415 | 9.8 | Fair |
| 6/11/2012 | 1143 | 1209 | 10.7 | Fair |
| 8/3/2012 | 1341 | 1421 | 10.0 | Fair |
| 8/16/2012 | 1200 | 1246 | 8.7 | Fair |
| 9/1/2012 | 1806 | 1841 | 18.0 | Fair |
| 9/14/2012 | 1226 | 1258 | 11.0 | Fair |
| 6/24/2013 | 1131 | 1150 | 17.8 | Poor |
| 6/29/2013 | 1950 | 2012 | 14.3 | Poor |
| 7/13/2013 | 1239 | 1256 | 13.8 | Poor |
| 7/26/2013 | 1008 | 1026 | 13.6 | Poor |
| 8/9/2013 | 1012 | 1030 | 13.6 | Poor |
| 8/26/2013 | 1007 | 1026 | 16.5 | Poor |
| 9/9/2013 | 1000 | 1020 | 16.4 | Poor |
| 9/19/2013 | 1221 | 1241 | 28.3 | Poor |
| 9/26/2013 | 1304 | 1222 | 36.2 | Poor |

Table 12.–Mean of daily mean flows ($ft^3/s$) by calendar day for the Meadow Creek discharge station based on the entire period of record (16 July 2008 to 30 September 2013).

| Day | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.7 | 4.3 | 3.9 | 4.6 | 19 | 13 | 8.7 | 8.4 | 9.2 | 17 | 7.7 | 5.4 |
| 2 | 4.7 | 4.2 | 4.1 | 4.7 | 19 | 12 | 8.7 | 8.3 | 9.3 | 16 | 7.7 | 5.3 |
| 3 | 4.7 | 4.1 | 4.2 | 4.9 | 19 | 13 | 8.4 | 8.3 | 9.4 | 15 | 7.5 | 5.0 |
| 4 | 4.4 | 4.0 | 4.3 | 5.2 | 19 | 13 | 8.5 | 8.2 | 9.8 | 15 | 7.5 | 5.1 |
| 5 | 4.3 | 4.0 | 4.3 | 5.5 | 20 | 13 | 8.4 | 8.3 | 11 | 15 | 7.3 | 5.1 |
| 6 | 4.3 | 4.0 | 4.3 | 5.8 | 19 | 13 | 8.2 | 8.3 | 11 | 17 | 7.6 | 5.2 |
| 7 | 4.2 | 4.2 | 4.4 | 6.3 | 19 | 13 | 8.1 | 8.6 | 11 | 19 | 7.3 | 5.1 |
| 8 | 4.0 | 4.1 | 4.5 | 6.5 | 19 | 12 | 8.1 | 8.6 | 11 | 19 | 7.3 | 5.2 |
| 9 | 4.0 | 4.3 | 4.5 | 6.8 | 18 | 12 | 8.2 | 8.9 | 11 | 19 | 7.3 | 5.4 |
| 10 | 3.9 | 4.4 | 4.6 | 7.2 | 17 | 12 | 8 | 9.1 | 11 | 18 | 7.3 | 5.6 |
| 11 | 4.0 | 4.6 | 4.3 | 7.6 | 17 | 12 | 7.9 | 9.2 | 11 | 17 | 7.4 | 5.7 |
| 12 | 4.1 | 4.5 | 4.3 | 8.1 | 18 | 12 | 7.7 | 9.2 | 12 | 17 | 7.5 | 5.9 |
| 13 | 3.9 | 4.7 | 4.4 | 8.7 | 17 | 12 | 7.8 | 9.1 | 12 | 16 | 7.4 | 5.8 |
| 14 | 4.0 | 5.0 | 4.2 | 9.3 | 16 | 12 | 7.9 | 8.9 | 12 | 16 | 7.3 | 5.8 |
| 15 | 3.9 | 4.9 | 4.2 | 10 | 15 | 11 | 7.7 | 8.6 | 12 | 15 | 7.3 | 5.8 |
| 16 | 4.1 | 4.8 | 4.3 | 11 | 15 | 11 | 7.6 | 8.6 | 12 | 15 | 6.9 | 5.9 |
| 17 | 3.8 | 4.7 | 4.1 | 12 | 15 | 11 | 8.4 | 8.6 | 13 | 14 | 7.0 | 5.8 |
| 18 | 3.9 | 4.7 | 4.1 | 14 | 16 | 11 | 8.7 | 8.8 | 14 | 13 | 6.8 | 5.8 |
| 19 | 4.0 | 4.6 | 3.9 | 16 | 15 | 10 | 8.7 | 9 | 15 | 13 | 6.6 | 5.8 |
| 20 | 4.0 | 4.4 | 3.9 | 18 | 15 | 10 | 8.8 | 9.2 | 17 | 13 | 6.2 | 5.8 |
| 21 | 4.3 | 4.3 | 3.8 | 20 | 14 | 9.6 | 9.1 | 9.2 | 20 | 12 | 6.2 | 5.8 |
| 22 | 4.4 | 4.2 | 3.8 | 21 | 14 | 9.2 | 8.9 | 9.5 | 23 | 12 | 6.0 | 5.5 |
| 23 | 4.4 | 4.2 | 3.8 | 23 | 14 | 9.1 | 8.8 | 10 | 23 | 12 | 5.4 | 5.4 |
| 24 | 4.5 | 4.0 | 3.9 | 26 | 13 | 8.9 | 8.9 | 10 | 22 | 11 | 5.4 | 5.3 |
| 25 | 4.4 | 4.0 | 3.9 | 29 | 13 | 8.8 | 9.3 | 9.6 | 22 | 10 | 5.1 | 5.4 |
| 26 | 4.1 | 4.0 | 3.9 | 30 | 13 | 9.4 | 9.4 | 9 | 21 | 9.9 | 5.1 | 5.3 |
| 27 | 4.0 | 3.8 | 4.0 | 26 | 12 | 9.0 | 9.7 | 8.9 | 21 | 9.4 | 5.1 | 5.3 |
| 28 | 4.0 | 3.7 | 4.1 | 26 | 13 | 9.0 | 9.4 | 9.1 | 20 | 9.2 | 5.3 | 5.1 |
| 29 | 3.9 | - | 4.3 | 23 | 12 | 8.9 | 9.1 | 9.3 | 19 | 8.6 | 5.3 | 5.0 |
| 30 | 4.1 | - | 4.4 | 21 | 13 | 8.7 | 8.7 | 9.2 | 18 | 8.2 | 5.4 | 5.0 |
| 31 | 4.1 | - | 4.5 | - | 13 | - | 8.5 | 9.2 | - | 7.7 | - | 4.9 |

Table 13.–Monthly exceedance and monthly mean flows ($ft^3/s$) for Meadow Creek discharge station, based on complete months of record (1 August 2008 to 30 September 2013).

| % Time exceeded | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 9.2 | 11 | 9.5 | 77 | 44 | 30 | 14 | 18 | 84 | 63 | 15 | 11 |
| 5 | 7.2 | 8.8 | 8.5 | 40 | 37 | 24 | 13 | 12 | 56 | 51 | 14 | 10 |
| 10 | 6.1 | 7.5 | 6.8 | 28 | 34 | 20 | 12 | 11 | 28 | 41 | 13 | 9.5 |
| 15 | 5.8 | 5.8 | 5.8 | 21 | 28 | 15 | 11 | 11 | 23 | 27 | 8.8 | 6.8 |
| 20 | 5.1 | 5.5 | 5.0 | 18 | 24 | 13 | 11 | 10 | 20 | 13 | 7.3 | 6.5 |
| 25 | 4.8 | 5.3 | 4.5 | 17 | 19 | 13 | 10 | 9.8 | 14 | 12 | 6.5 | 6.1 |
| 30 | 4.5 | 5.0 | 4.3 | 15 | 16 | 12 | 10 | 9.5 | 12 | 11 | 6.1 | 5.8 |
| 35 | 3.9 | 4.7 | 4.3 | 13 | 15 | 11 | 9.8 | 9.3 | 11 | 8.7 | 6.1 | 5.1 |
| 40 | 3.8 | 3.8 | 4.1 | 12 | 14 | 11 | 9.5 | 9.1 | 11 | 7.9 | 6.1 | 5.1 |
| 45 | 3.5 | 3.8 | 3.7 | 11 | 13 | 9.6 | 8.2 | 8.9 | 10 | 7.5 | 5.8 | 4.8 |
| 50 | 3.5 | 3.5 | 3.5 | 10 | 13 | 9.0 | 7.0 | 8.8 | 9.3 | 7.4 | 5.8 | 4.8 |
| 55 | 3.5 | 3.5 | 3.5 | 9.2 | 11 | 8.2 | 6.5 | 8.6 | 8.8 | 7.2 | 5.8 | 4.5 |
| 60 | 3.5 | 3.3 | 3.3 | 8.2 | 11 | 8.0 | 6.3 | 8.5 | 8.2 | 7.1 | 5.5 | 4.5 |
| 65 | 3.4 | 3.1 | 3.2 | 7.2 | 10 | 7.6 | 6.0 | 8.3 | 7.6 | 6.9 | 5.5 | 4.3 |
| 70 | 3.3 | 3.0 | 3.1 | 6.8 | 9.7 | 7.3 | 5.9 | 8.1 | 7.0 | 6.8 | 5.1 | 4.1 |
| 75 | 3.3 | 2.8 | 3.1 | 6.1 | 9.4 | 7.0 | 5.8 | 7.7 | 6.7 | 6.6 | 5.1 | 4.1 |
| 80 | 3.1 | 2.8 | 3.1 | 5.8 | 8.9 | 6.6 | 5.6 | 7.4 | 6.5 | 6.5 | 4.8 | 4.0 |
| 85 | 3.1 | 2.7 | 2.6 | 5.1 | 8.3 | 6.5 | 5.6 | 6.8 | 6.3 | 6.4 | 4.3 | 3.9 |
| 90 | 3.0 | 2.6 | 2.6 | 4.4 | 7.8 | 6.3 | 5.4 | 6.5 | 6.3 | 6.2 | 4.1 | 3.8 |
| 95 | 2.8 | 2.5 | 2.5 | 4.1 | 7.1 | 6.1 | 5.2 | 6.2 | 6.2 | 6.1 | 3.9 | 3.7 |
| 100 | 2.5 | 2.3 | 2.5 | 3.8 | 6.4 | 5.6 | 5.0 | 5.3 | 6.1 | 5.9 | 3.8 | 2.8 |
| Mean | 4.2 | 4.3 | 4.2 | 14 | 16 | 11 | 8.1 | 8.9 | 15 | 14 | 6.6 | 5.4 |

Figure 1.–Location of Fish and Meadow Creeks in the Big Lake drainage near Wasilla, Alaska.

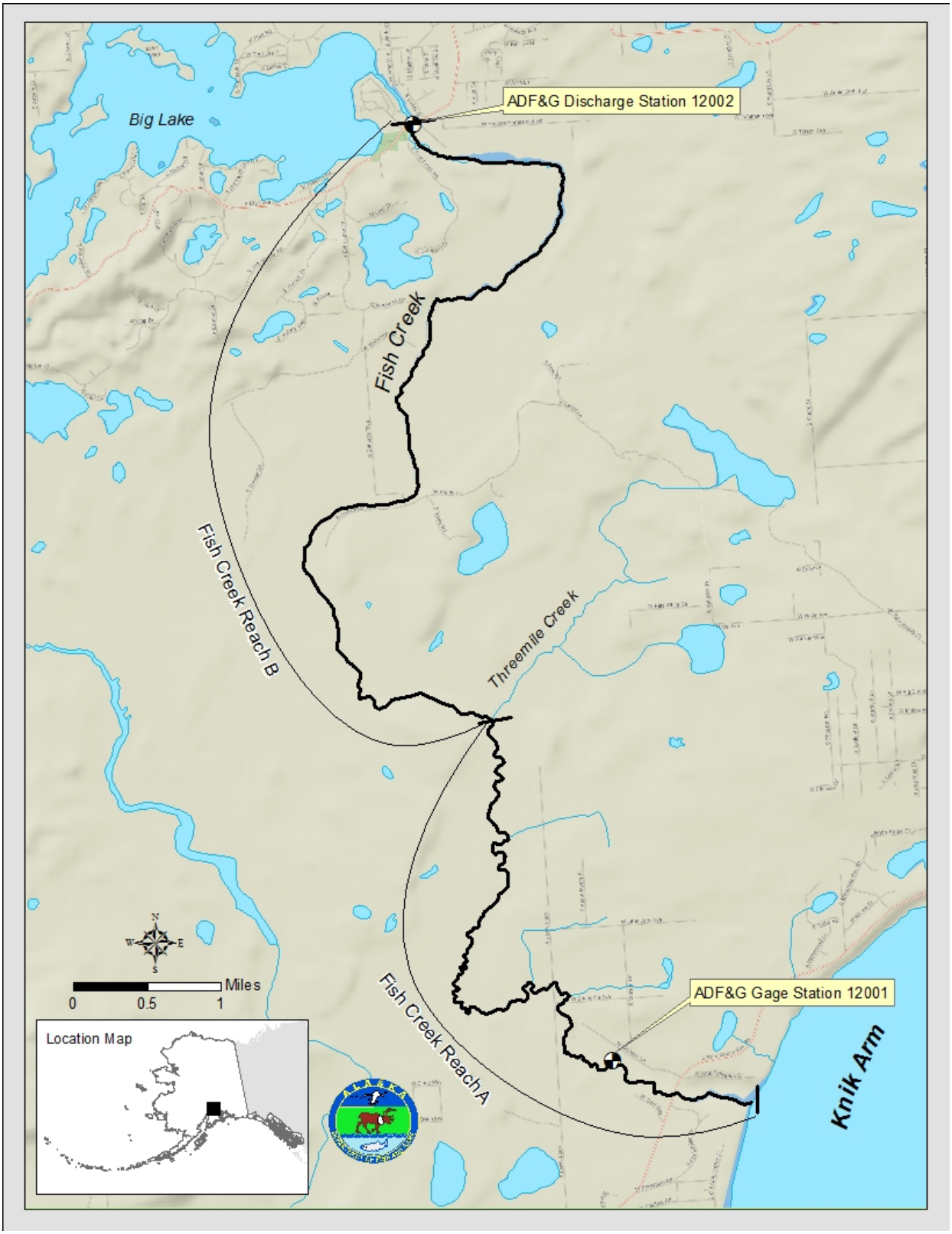



Figure 2.–Location of reservation of water reach boundaries and gaging and discharge stations on Fish Creek, Alaska.

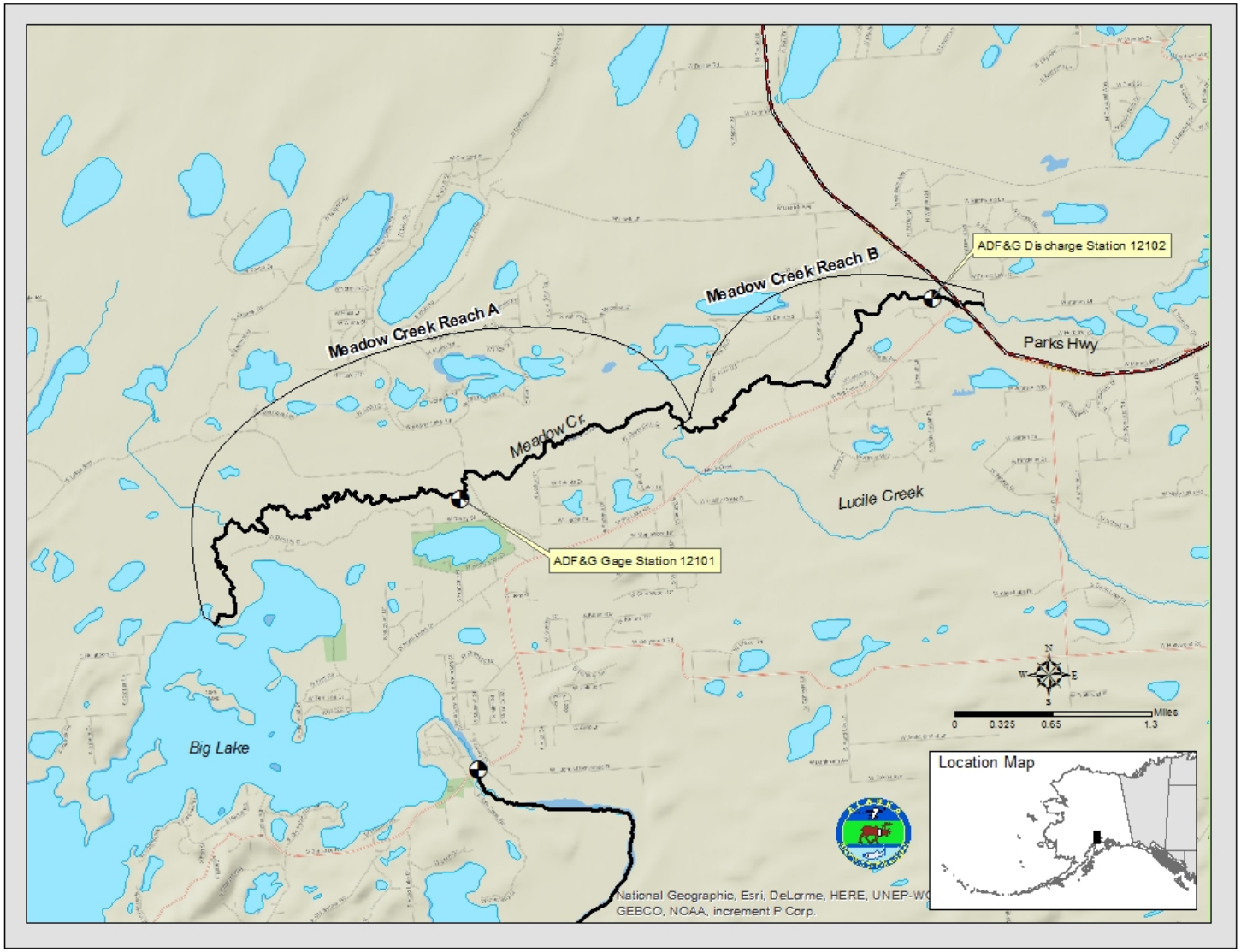



Figure 3.–Location of reservation of water reach boundaries and gaging and discharge stations on Meadow Creek, Alaska.

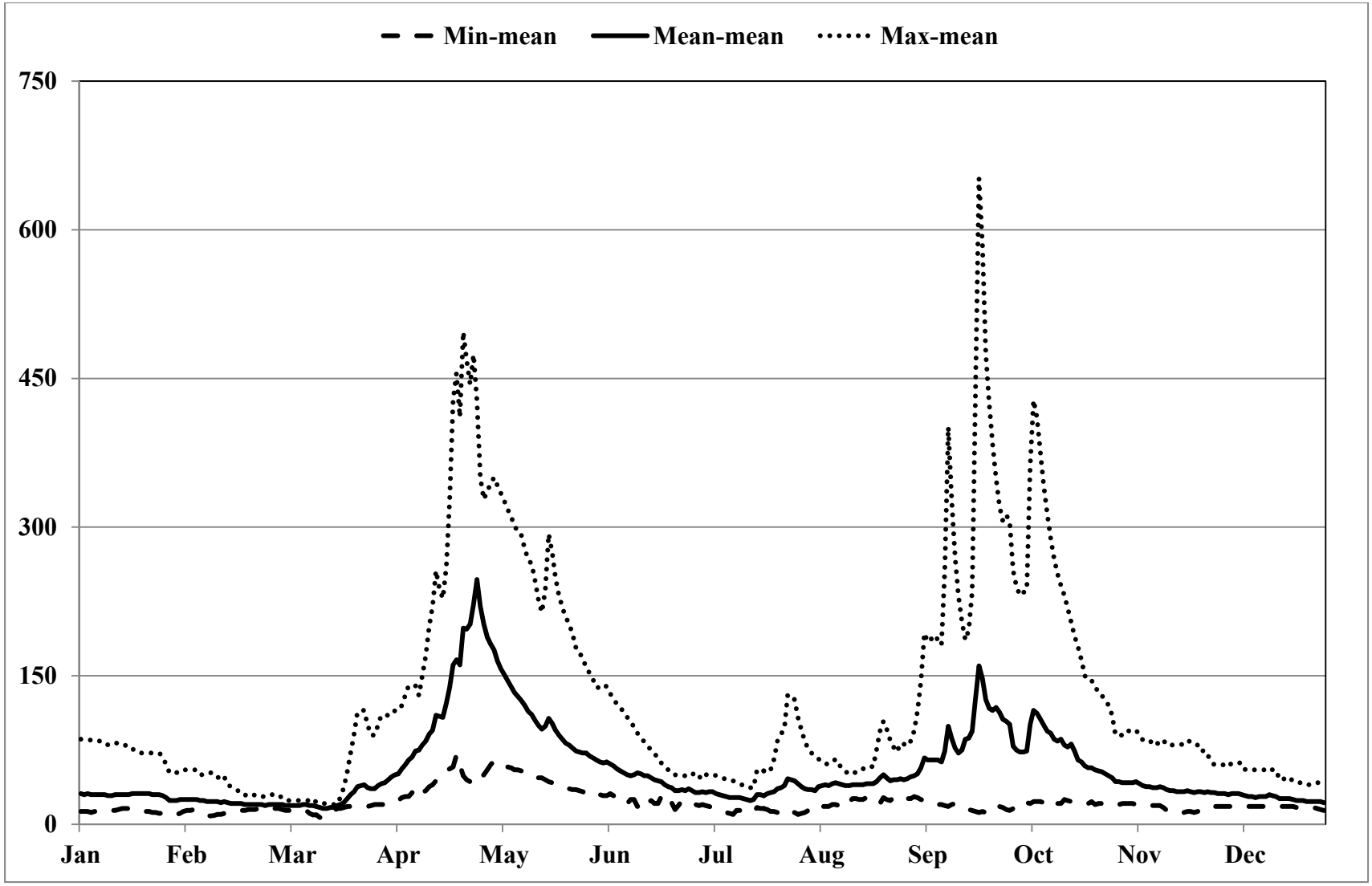



Figure 4.–Hydrograph of minimum, mean, and maximum daily mean flows ($ft^3/s$) for the Fish Creek gaging station based on the entire period of record (16 July 2008 to 30 September 2013).

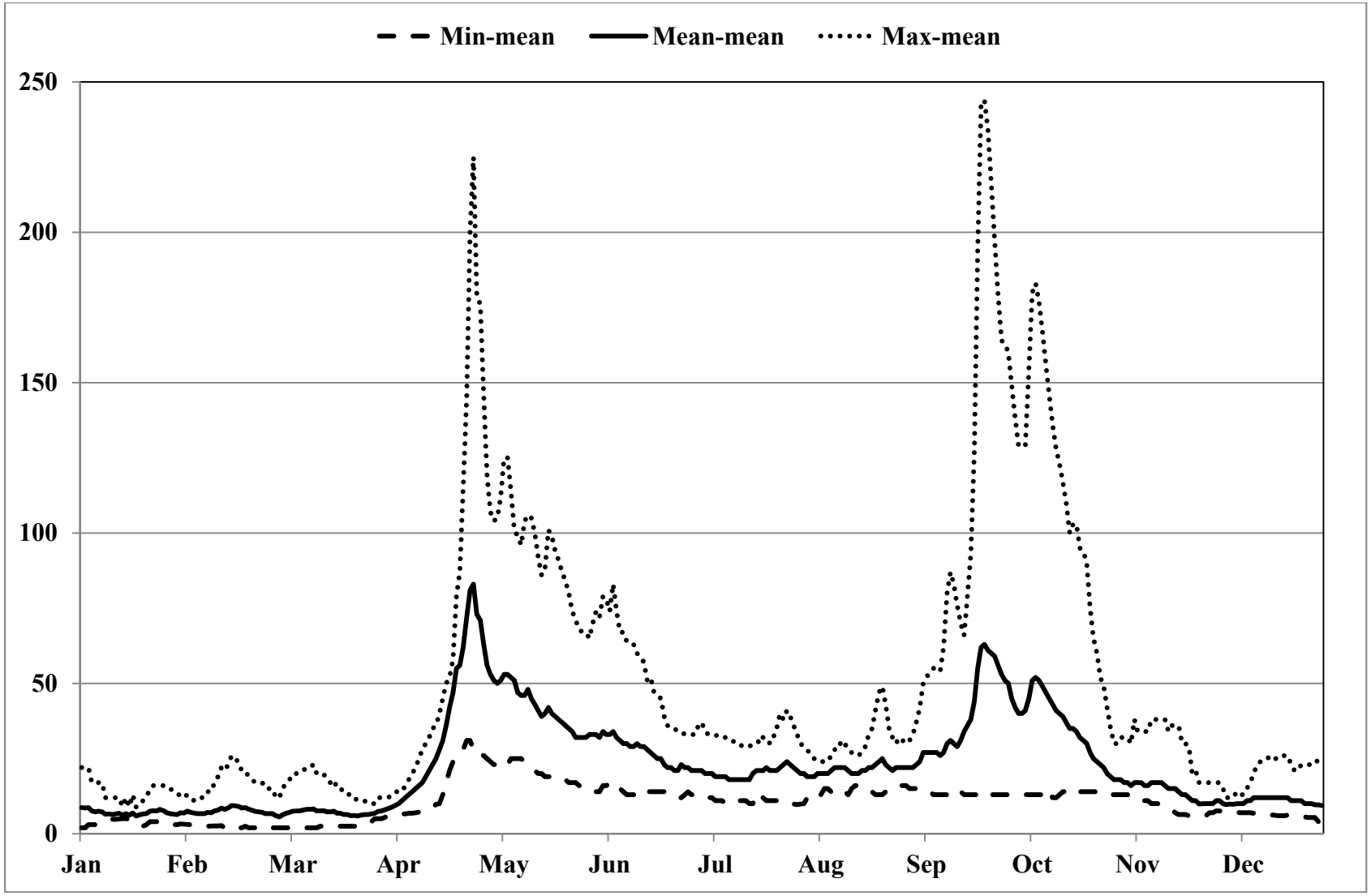



Figure 5.–Hydrograph of minimum, mean, and maximum daily mean flows ($ft^3/s$) for Meadow Creek gaging station based on entire period of record (16 July 2008 to 30 September 2013).

# APPENDIX A.
# DAILY MEAN FLOWS BY WATER YEAR FOR THE FISH AND MEADOW CREEK GAGES

Appendix A1.–Daily mean flow ($ft^3/s$) for the Fish Creek gaging station, water years 2008 (partial) and 2009 (*e* indicates estimated flow).

| Day | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | - | 83 | 33 | 69 | e49 | e33 | e13 | e24 | e19 | e22 | 228 | 57 | 30 | 16 | 26 |
| 2 | - | 76 | 31 | 67 | e48 | e31 | e13 | e23 | e19 | e23 | 209 | 55 | 28 | 14 | 28 |
| 3 | - | 72 | 29 | 65 | e47 | e30 | e13 | e22 | e19 | e23 | 188 | 53 | 28 | 13 | 27 |
| 4 | - | 68 | 31 | 65 | e47 | e30 | e12 | e22 | e20 | e24 | 170 | 51 | 27 | 13 | 25 |
| 5 | - | 66 | 33 | 64 | e47 | e30 | e13 | e23 | e21 | e27 | 157 | 50 | 26 | 18 | 24 |
| 6 | - | 64 | 32 | 68 | e47 | e29 | e13 | e23 | e21 | e28 | 145 | 48 | 26 | 25 | 23 |
| 7 | - | 61 | 34 | 69 | e46 | e28 | e13 | e22 | e22 | e28 | 134 | 46 | 25 | 25 | 22 |
| 8 | - | 61 | 34 | 67 | e46 | e27 | e13 | e21 | e23 | e32 | 125 | 42 | 25 | 24 | 22 |
| 9 | - | 60 | 44 | 64 | e46 | e25 | e13 | e20 | e23 | e34 | 118 | 41 | 26 | 22 | 20 |
| 10 | - | 60 | 45 | 69 | e47 | e23 | e14 | e19 | e23 | e38 | 111 | 39 | 25 | 20 | 20 |
| 11 | - | 58 | 45 | 70 | e48 | e22 | e14 | e19 | e22 | e32 | 105 | 38 | 25 | 19 | 19 |
| 12 | - | 55 | 45 | 77 | e47 | e21 | e15 | e20 | e22 | e34 | 98 | 37 | 24 | 17 | 18 |
| 13 | - | 53 | 48 | 77 | e46 | e20 | e17 | e21 | e21 | e38 | 91 | 39 | 23 | 17 | 20 |
| 14 | - | 51 | 49 | 76 | e45 | e20 | e21 | e22 | e21 | e40 | 84 | 38 | 22 | 23 | 21 |
| 15 | - | 50 | 49 | 80 | e44 | e20 | e25 | e24 | e21 | e44 | 86 | 36 | 21 | 30 | 20 |
| 16 | 25 | 48 | 52 | 79 | e42 | e20 | e29 | e25 | e20 | e48 | 87 | 35 | 17 | 32 | 19 |
| 17 | 37 | 47 | 69 | 76 | e40 | e20 | e34 | e25 | e20 | e50 | 82 | 33 | 16 | 31 | 17 |
| 18 | 55 | 45 | 72 | 105 | e38 | e20 | e35 | e25 | e19 | e54 | 76 | 31 | 17 | 29 | 15 |
| 19 | 56 | 43 | 71 | 88 | e36 | e19 | e36 | e24 | e19 | e56 | 72 | 33 | 16 | 27 | 14 |
| 20 | 54 | 42 | 71 | e60 | e36 | e18 | e36 | e23 | e19 | e58 | 69 | 33 | 15 | 25 | 13 |
| 21 | 52 | 41 | 74 | e59 | e36 | e18 | e37 | e22 | e19 | e70 | 65 | 31 | 15 | 22 | 12 |
| 22 | 55 | 43 | 72 | e59 | e35 | e18 | e35 | e21 | e20 | e82 | 62 | 31 | 13 | 20 | 13 |
| 23 | 66 | 42 | 71 | e58 | e35 | e17 | e34 | e20 | e20 | e96 | 59 | 33 | 13 | 21 | 12 |
| 24 | 84 | 43 | 86 | e58 | e35 | e17 | e33 | e20 | e21 | e120 | 56 | 34 | 11 | 27 | 11 |
| 25 | 90 | 41 | 91 | e56 | e36 | e17 | e32 | e20 | e22 | e160 | 54 | 33 | 11 | 25 | 16 |
| 26 | 96 | 41 | 87 | e55 | e36 | e17 | e31 | e19 | e23 | e220 | 52 | 33 | 13 | 24 | 21 |
| 27 | 131 | 39 | 83 | e54 | e37 | e17 | e29 | e19 | e24 | 427 | 50 | 32 | 15 | 27 | 20 |
| 28 | 127 | 39 | 78 | e51 | e37 | e17 | e27 | e19 | e24 | 350 | 55 | 33 | 16 | 27 | 21 |
| 29 | 126 | 37 | 76 | e50 | e36 | e16 | e25 | - | e23 | 298 | 56 | 32 | 20 | 29 | - |
| 30 | 108 | 36 | 73 | e50 | e35 | e15 | e25 | - | e23 | 255 | 54 | 31 | 20 | 28 | - |
| 31 | 95 | 35 | - | e49 | - | e14 | e25 | - | e22 | - | 56 | - | 19 | 26 | - |
| Mean | 79 | 52 | 57 | 66 | 42 | 22 | 23 | 22 | 21 | 94 | 99 | 39 | 20 | 23 | 19 |
| Max | 131 | 83 | 91 | 105 | 49 | 33 | 37 | 25 | 24 | 427 | 228 | 57 | 30 | 32 | 28 |
| Min | 25 | 35 | 29 | 49 | 35 | 14 | 13 | 19 | 19 | 22 | 50 | 31 | 11 | 13 | 11 |

Appendix A2.–Daily mean flow ($ft^3/s$) for the Fish Creek gaging station, water year 2010 (*e* indicates estimated flow).

| Day | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 15 | e27 | e26 | e21 | e14 | e21 | e35 | e60 | 39 | 22 | 47 | 41 |
| 2 | 14 | e26 | e25 | e20 | e14 | e21 | e36 | e66 | 32 | 23 | 45 | 40 |
| 3 | 16 | e25 | e25 | e20 | e15 | e20 | e37 | e62 | 29 | 23 | 43 | 38 |
| 4 | 18 | e23 | e24 | e20 | e13 | e19 | e38 | e59 | 33 | 26 | 46 | 41 |
| 5 | 23 | e24 | e24 | e19 | e11 | e18 | e38 | 58 | 32 | 29 | 53 | 52 |
| 6 | 21 | e27 | e24 | e19 | e10 | e18 | e39 | 58 | 28 | 27 | 53 | 51 |
| 7 | 27 | e25 | e23 | e19 | e9 | e19 | e39 | 56 | 25 | 25 | 52 | 54 |
| 8 | 33 | e20 | e23 | e18 | e8.5 | e19 | e40 | 55 | 22 | 23 | 51 | 55 |
| 9 | 39 | e19 | e22 | e18 | e9 | e18 | e40 | 55 | 22 | 22 | 51 | 52 |
| 10 | 39 | e20 | e22 | e18 | e10 | e18 | e41 | 54 | 21 | 23 | 49 | 50 |
| 11 | 40 | e19 | e21 | e17 | e10 | e17 | e42 | 53 | 25 | 25 | 47 | 48 |
| 12 | 40 | e20 | e22 | e17 | e11 | e17 | e43 | 51 | 25 | 22 | 46 | 46 |
| 13 | 39 | e19 | e22 | e16 | e12 | e16 | e45 | 52 | 18 | 22 | 45 | 45 |
| 14 | 38 | e17 | e21 | e16 | e12 | e16 | e47 | 50 | 18 | 21 | 47 | 43 |
| 15 | 39 | e14 | e23 | e16 | e13 | e15 | e50 | 48 | 15 | 19 | 46 | 42 |
| 16 | 39 | e13 | e23 | e15 | e13 | e15 | e55 | 48 | 22 | 18 | 45 | 41 |
| 17 | 38 | e13 | e24 | e15 | e14 | e16 | e60 | 47 | 24 | 16 | 47 | 40 |
| 18 | 37 | e12 | e24 | e14 | e14 | e16 | e65 | 45 | 21 | 19 | 46 | 39 |
| 19 | 36 | e12 | e25 | e14 | e15 | e17 | e70 | 44 | 21 | 21 | 44 | 38 |
| 20 | 34 | e12 | e26 | e13 | e15 | e18 | e90 | 45 | 28 | 23 | 41 | 36 |
| 21 | 33 | e13 | e26 | e13 | e15 | e19 | e75 | 44 | 22 | 35 | 40 | 36 |
| 22 | 32 | e13 | e25 | e12 | e16 | e20 | e60 | 42 | 25 | 34 | 40 | 34 |
| 23 | 30 | e12 | e26 | e12 | e16 | e21 | e49 | 41 | 22 | 34 | 40 | 33 |
| 24 | 27 | e13 | e25 | e11 | e15 | e23 | e45 | 40 | 15 | 31 | 39 | 30 |
| 25 | 27 | e15 | e25 | e11 | e16 | e24 | e43 | 38 | 19 | 32 | 37 | 24 |
| 26 | 26 | e20 | e24 | e10 | e17 | e25 | e40 | 37 | 24 | 41 | 35 | 25 |
| 27 | 27 | e23 | e23 | e9.0 | e18 | e27 | e42 | 36 | 24 | 51 | 35 | 23 |
| 28 | 27 | e24 | e23 | e9.5 | e19 | e28 | e46 | 36 | 34 | 50 | 38 | 22 |
| 29 | 27 | e25 | e23 | e9.9 | - | e30 | e50 | 46 | 25 | 50 | 46 | 22 |
| 30 | e30 | e26 | e22 | e11 | - | e32 | e55 | 44 | 24 | 49 | 44 | 25 |
| 31 | e28 | - | e21 | e13 | - | e33 | - | 44 | - | 49 | 43 | - |
| Mean | 30 | 19 | 24 | 15 | 13 | 21 | 49 | 49 | 25 | 29 | 44 | 39 |
| Max | 40 | 27 | 26 | 21 | 20 | 33 | 90 | 66 | 39 | 51 | 53 | 55 |
| Min | 14 | 12 | 21 | 9.0 | 9.0 | 15 | 35 | 36 | 15 | 16 | 35 | 22 |

Appendix A3.–Daily mean flow ($ft^3/s$) for the Fish Creek gaging station, water year 2011 (*e* indicates estimated flow).

| Day | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 31 | e20 | e18 | e17 | e16 | e15 | e110 | 65 | 30 | 19 | 12 | 50 |
| 2 | 29 | e21 | e18 | e17 | e16 | e14 | e110 | 64 | 30 | 20 | 17 | 48 |
| 3 | 29 | e21 | e18 | e18 | e16 | e14 | e115 | 62 | 29 | 19 | 23 | 47 |
| 4 | 27 | e21 | e18 | e18 | e15 | e14 | e115 | 62 | 29 | 18 | 23 | 45 |
| 5 | 27 | e21 | e18 | e18 | e15 | e14 | e120 | 63 | 31 | 17 | 32 | 43 |
| 6 | 28 | e20 | e18 | e18 | e15 | e14 | e130 | 61 | 31 | 15 | 37 | 40 |
| 7 | 30 | e20 | e18 | e18 | e15 | e14 | e140 | 59 | 29 | 14 | 46 | 36 |
| 8 | 29 | e20 | e18 | e18 | e16 | e14 | e140 | 59 | 29 | 13 | 47 | 34 |
| 9 | 29 | e20 | e18 | e18 | e16 | e11 | e140 | 60 | 28 | 12 | 62 | 33 |
| 10 | 28 | e20 | e18 | e18 | e15 | 10 | e130 | 60 | 26 | 11 | 66 | 32 |
| 11 | 27 | e20 | e18 | e18 | e15 | 10 | e130 | 59 | 25 | 10 | 61 | 30 |
| 12 | 27 | e20 | e18 | e17 | e15 | 6.9 | e130 | 54 | 30 | 14 | 55 | 30 |
| 13 | 26 | e20 | e18 | e17 | e15 | 6.6 | e120 | 51 | 36 | 14 | 50 | 30 |
| 14 | 35 | e20 | e18 | e17 | e15 | 7.3 | e115 | 49 | 35 | 14 | 47 | 28 |
| 15 | 48 | e20 | e18 | e16 | e15 | 10 | e135 | 47 | 35 | 13 | 53 | 27 |
| 16 | 25 | e19 | e18 | e16 | e15 | 13 | e115 | 47 | 39 | 12 | 52 | 26 |
| 17 | 24 | e19 | e18 | e16 | e15 | 20 | 102 | 45 | 37 | 12 | 53 | 25 |
| 18 | 23 | e19 | e18 | e16 | e15 | 27 | 96 | 43 | 34 | 24 | 56 | 26 |
| 19 | 22 | e19 | e18 | e16 | e15 | 37 | 90 | 42 | 32 | 22 | 57 | 26 |
| 20 | 22 | e19 | e18 | e16 | e15 | 53 | 82 | 41 | 31 | 18 | 59 | 25 |
| 21 | 22 | e18 | e18 | e16 | e15 | 71 | 74 | 40 | 30 | 16 | 56 | 24 |
| 22 | 22 | e18 | e18 | e16 | e15 | 90 | 72 | 39 | 28 | 15 | 53 | 23 |
| 23 | 21 | e18 | e18 | e17 | e15 | 113 | 69 | 38 | 27 | 13 | 54 | 21 |
| 24 | 23 | e19 | e18 | e17 | e15 | 115 | 65 | 36 | 25 | 15 | 51 | 20 |
| 25 | 20 | e19 | e17 | e16 | e15 | 115 | 69 | 35 | 25 | 18 | 48 | 19 |
| 26 | 21 | e19 | e17 | e16 | e15 | 100 | 71 | 35 | 25 | 16 | 45 | 18 |
| 27 | 21 | e19 | e17 | e16 | e15 | 90 | 73 | 33 | 24 | 14 | 43 | 18 |
| 28 | 21 | e19 | e17 | e16 | e15 | 90 | 75 | 33 | 23 | 13 | 41 | 17 |
| 29 | e21 | e19 | e17 | e16 | - | 100 | 73 | 31 | 22 | 11 | 38 | 15 |
| 30 | e20 | e18 | e17 | e16 | - | 110 | 68 | 30 | 20 | 10 | 37 | 14 |
| 31 | e20 | - | e17 | e16 | - | 110 | - | 28 | - | 11 | 44 | - |
| Mean | 26 | 20 | 18 | 17 | 15 | 46 | 102 | 47 | 29 | 15 | 46 | 29 |
| Max | 48 | 21 | 18 | 18 | 16 | 115 | 140 | 65 | 39 | 24 | 66 | 50 |
| Min | 20 | 18 | 17 | 16 | 15 | 6.6 | 65 | 28 | 20 | 10 | 12 | 14 |

Appendix A4.–Daily mean flow ($ft^3/s$) for the Fish Creek gaging station, water year 2012 (*e* indicates estimated flow).

| Day | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 23 | e27 | e19 | e17 | e17 | e17 | e26 | 211 | 63 | 46 | 33 | 52 |
| 2 | 23 | e27 | e19 | e17 | e17 | e18 | e35 | 191 | 60 | 43 | 37 | 52 |
| 3 | 23 | e26 | e19 | e17 | e17 | e18 | e40 | 173 | 60 | 41 | 38 | 53 |
| 4 | 22 | e24 | e20 | e17 | e17 | e18 | e45 | 161 | 63 | 44 | 37 | 54 |
| 5 | 22 | e24 | e20 | e17 | e17 | e19 | e55 | 151 | 60 | 42 | 38 | 60 |
| 6 | 22 | e24 | e20 | e17 | e17 | e19 | e65 | 142 | 59 | 40 | 36 | 61 |
| 7 | 23 | e24 | e20 | e17 | e17 | e19 | e80 | 133 | 60 | 39 | 35 | 58 |
| 8 | 23 | e23 | e21 | e17 | e17 | e19 | e85 | 125 | 58 | 38 | 34 | 57 |
| 9 | 23 | e21 | e21 | e17 | e18 | e19 | e110 | 117 | 56 | 36 | 32 | 54 |
| 10 | 22 | e19 | e21 | e17 | e18 | e18 | e120 | 111 | 53 | 34 | 32 | 51 |
| 11 | 22 | e19 | e21 | e18 | e18 | e18 | e150 | 106 | 52 | 32 | 31 | 47 |
| 12 | 25 | e19 | e22 | e18 | e18 | e18 | e170 | 102 | 58 | 32 | 29 | 52 |
| 13 | 21 | e19 | e24 | e18 | e18 | e18 | e200 | 100 | 76 | 34 | 28 | 51 |
| 14 | 21 | e19 | e27 | e17 | e18 | e18 | e220 | 96 | 80 | 32 | 27 | 52 |
| 15 | 20 | e18 | e33 | e17 | e18 | e18 | 256 | 90 | 76 | 36 | 26 | 62 |
| 16 | 28 | e18 | e28 | e17 | e18 | e18 | 238 | 86 | 72 | 37 | 26 | 108 |
| 17 | 34 | e18 | e25 | e17 | e18 | e19 | 228 | 82 | 67 | 35 | 25 | 181 |
| 18 | 34 | e17 | e22 | e17 | e17 | e19 | 260 | 79 | 67 | 33 | 25 | 196 |
| 19 | 33 | e17 | e21 | e17 | e17 | e19 | 326 | 76 | 65 | 32 | 27 | 235 |
| 20 | 33 | e17 | e21 | e17 | e17 | e18 | 428 | 72 | 61 | 31 | 29 | 437 |
| 21 | 32 | e17 | e21 | e17 | e17 | e18 | 455 | 70 | 57 | 37 | 31 | 652 |
| 22 | 32 | e17 | e19 | e17 | e17 | e18 | 411 | 68 | 54 | 45 | 31 | 585 |
| 23 | 31 | e17 | e19 | e17 | e17 | e18 | 497 | 65 | 51 | 45 | 34 | 475 |
| 24 | 32 | e17 | e19 | e16 | e17 | e18 | 468 | 65 | 50 | 45 | 36 | 424 |
| 25 | 32 | e17 | e19 | e16 | e17 | e19 | 444 | 68 | 49 | 43 | 34 | 384 |
| 26 | 34 | e17 | e19 | e16 | e17 | e19 | 474 | 67 | 49 | 40 | 34 | 349 |
| 27 | 35 | e17 | e19 | e16 | e17 | e19 | 378 | 67 | 49 | 38 | 48 | 321 |
| 28 | 30 | e18 | e18 | e16 | e17 | e20 | 311 | 70 | 51 | 36 | 50 | 306 |
| 29 | 28 | e18 | e18 | e16 | e17 | e20 | 259 | 68 | 52 | 34 | 46 | 312 |
| 30 | 27 | e18 | e18 | e16 | - | e22 | 232 | 64 | 48 | 34 | 45 | 306 |
| 31 | 27 | - | e18 | e16 | - | e25 | - | 62 | - | 33 | 49 | - |
| Mean | 27 | 20 | 21 | 17 | 17 | 19 | 236 | 101 | 59 | 38 | 34 | 203 |
| Max | 35 | 27 | 33 | 17 | 17 | 25 | 497 | 211 | 80 | 46 | 50 | 652 |
| Min | 20 | 17 | 18 | 16 | 17 | 17 | 26 | 62 | 48 | 31 | 25 | 47 |

Appendix A5.–Daily mean flow ($ft^3/s$) for the Fish Creek gaging station, water year 2013 (*e* indicates estimated flow).

| Day | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 256 | e90 | e60 | e86 | e55 | e26 | e30 | e344 | 138 | 46 | 22 | 84 |
| 2 | 240 | e90 | e60 | e85 | e55 | e24 | e35 | e350 | 138 | 51 | 21 | 94 |
| 3 | 231 | e90 | e58 | e85 | e55 | e24 | e35 | e342 | 141 | 50 | 20 | 114 |
| 4 | 234 | e95 | e62 | e85 | e55 | e24 | e35 | e334 | 139 | 50 | 19 | 144 |
| 5 | 236 | e95 | e62 | e85 | e50 | e24 | e40 | e326 | 132 | 51 | 18 | 192 |
| 6 | 363 | e95 | e62 | e85 | e50 | e24 | e40 | e318 | 127 | 49 | 18 | 184 |
| 7 | 428 | e90 | e62 | e83 | e50 | e24 | e40 | e310 | 121 | 48 | 18 | 187 |
| 8 | 410 | e85 | e55 | e83 | e52 | e24 | e43 | 391 | 117 | 47 | 18 | 191 |
| 9 | 374 | e85 | e55 | e80 | e52 | e24 | e45 | 324 | 113 | 45 | 20 | 186 |
| 10 | 341 | e85 | e55 | e80 | e48 | e26 | e44 | 292 | 108 | 44 | 25 | 181 |
| 11 | 313 | e80 | e55 | e82 | e45 | e22 | e44 | 278 | 104 | 44 | 29 | 257 |
| 12 | 289 | e80 | e55 | e82 | e48 | e20 | e45 | 266 | 98 | 42 | 40 | 400 |
| 13 | 268 | e85 | e55 | e82 | e40 | e20 | e50 | 263 | 92 | 41 | 41 | 329 |
| 14 | 252 | e85 | e55 | e80 | e38 | e20 | e55 | 246 | 88 | 39 | 39 | 270 |
| 15 | 241 | e80 | e57 | e76 | e36 | e20 | e67 | 226 | 83 | 37 | 36 | 231 |
| 16 | 231 | e80 | e55 | e76 | e34 | e18 | e89 | 214 | 79 | 36 | 34 | 205 |
| 17 | 218 | e80 | e55 | e75 | e34 | e20 | e100 | 237 | 75 | 35 | 37 | 186 |
| 18 | 204 | e80 | e45 | e72 | e30 | e20 | e135 | 293 | 72 | 34 | 43 | 173 |
| 19 | 190 | e80 | e45 | e72 | e28 | e20 | e149 | 275 | 66 | 33 | 47 | 182 |
| 20 | 179 | e82 | e48 | e72 | e28 | e20 | e148 | 249 | 62 | 33 | 52 | 178 |
| 21 | 166 | e85 | e45 | e72 | e30 | e20 | e157 | 231 | 59 | 33 | 58 | 165 |
| 22 | e150 | e83 | e45 | e72 | e30 | e18 | e178 | 219 | 54 | 31 | 75 | 155 |
| 23 | e145 | e80 | e42 | e72 | e28 | e18 | e280 | 209 | 51 | 28 | 94 | 144 |
| 24 | e145 | e80 | e42 | e72 | e28 | e20 | e288 | 202 | 48 | 27 | 104 | 131 |
| 25 | e140 | e80 | e42 | e68 | e30 | e18 | e296 | 192 | 46 | 27 | 96 | 156 |
| 26 | e132 | e70 | e40 | e60 | e30 | e18 | e304 | 178 | 44 | 28 | 85 | 206 |
| 27 | e130 | e70 | e40 | e52 | e30 | e19 | e312 | 175 | 43 | 27 | 78 | 213 |
| 28 | e125 | e63 | e40 | e52 | e30 | e20 | e320 | 165 | 41 | 26 | 73 | 195 |
| 29 | e120 | e60 | e42 | e52 | - | e20 | e328 | 160 | 40 | 24 | 82 | 179 |
| 30 | e110 | e60 | e42 | e55 | - | e20 | e336 | 152 | 39 | 24 | 81 | 166 |
| 31 | e90 | - | e42 | e55 | - | e20 | - | 146 | - | 23 | 79 | - |
| Mean | 224 | 81 | 51 | 74 | 40 | 21 | 136 | 409 | 85 | 37 | 48 | 189 |
| Max | 428 | 95 | 62 | 86 | 55 | 26 | 336 | 1150 | 141 | 52 | 104 | 401 |
| Min | 90 | 60 | 40 | 52 | 28 | 18 | 30 | 146 | 39 | 23 | 18 | 84 |

Appendix A6.–Daily mean flow ($ft^3/s$) for the Meadow Creek gaging station, water years 2008 (partial) and 2009 (*e* indicates estimated flow).

| Day | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | - | 29 | 20 | 29 | e15 | e11 | e5.2 | e12 | e7.4 | e7.6 | 39 | 28 | 18 | 14 | 15 |
| 2 | - | 28 | 19 | 28 | e15 | e11 | e5.0 | e12 | e7.8 | e8.0 | 38 | 26 | 17 | 13 | 15 |
| 3 | - | 26 | 19 | 28 | e14 | e10 | e4.8 | e11 | e7.8 | e8.8 | 38 | 24 | 17 | 13 | 15 |
| 4 | - | 25 | 19 | 27 | e14 | e10 | e4.6 | e10 | e8.0 | e9.4 | 38 | 24 | 16 | 12 | 15 |
| 5 | - | 25 | 21 | 27 | e14 | e9.8 | e4.1 | e10 | e8.2 | e11 | 38 | 23 | 16 | 13 | 14 |
| 6 | - | 24 | 21 | 28 | e13 | e9.4 | e4.3 | e10 | e8.2 | e12 | 37 | 23 | 15 | 15 | 14 |
| 7 | - | 24 | 21 | 28 | e13 | e9.4 | e4.5 | e9.8 | e8.4 | e13 | 39 | 23 | 15 | 15 | 14 |
| 8 | - | 24 | 21 | 28 | e13 | e9.2 | e4.5 | e9.4 | e8.4 | e14 | 44 | 23 | 15 | 14 | 13 |
| 9 | - | 24 | 26 | 29 | e13 | e9.0 | e4.6 | e9.2 | e8.4 | e16 | 36 | 22 | 15 | 14 | 13 |
| 10 | - | 24 | 26 | 30 | e13 | e8.6 | e4.8 | e8.8 | e8.2 | e17 | 32 | 27 | 14 | 14 | 13 |
| 11 | - | 24 | 25 | 30 | e13 | e8.2 | e4.8 | e8.6 | e7.6 | e19 | 32 | 24 | 13 | 15 | 13 |
| 12 | - | 23 | 24 | 31 | e14 | e8.0 | e4.9 | e9.0 | e7.4 | e20 | 39 | 22 | 13 | 14 | 13 |
| 13 | - | 26 | 23 | 32 | e14 | e7.4 | e5.2 | e9.4 | e7.4 | e24 | 31 | 22 | 14 | 13 | 13 |
| 14 | - | 25 | 23 | 33 | e14 | e7.0 | e6.2 | e9.8 | e7.4 | e28 | 28 | 21 | 14 | 15 | 14 |
| 15 | - | 23 | 22 | 32 | e14 | e6.6 | e7.2 | e10 | e7.4 | e32 | 28 | 21 | 13 | 16 | 13 |
| 16 | 26 | 23 | 23 | e29 | e13 | e6.4 | e7.8 | e11 | e7.2 | e35 | 31 | 20 | 12 | 16 | 13 |
| 17 | 28 | 22 | 28 | e28 | e13 | e6.2 | e8.8 | e11 | e7.0 | e39 | 35 | 19 | 13 | 15 | 13 |
| 18 | 30 | 21 | 31 | e26 | e13 | e6.2 | e10 | e11 | e7.0 | e44 | 30 | 19 | 13 | 15 | 13 |
| 19 | 31 | 20 | 30 | e24 | e12 | e6.2 | e11 | e11 | e6.6 | e49 | 27 | 19 | 12 | 14 | 13 |
| 20 | 32 | 21 | 29 | e22 | e11 | e6.2 | e12 | e11 | e6.6 | e58 | 26 | 19 | 13 | 14 | 13 |
| 21 | 32 | 20 | 31 | e20 | e11 | e6.2 | e15 | e9.6 | e6.6 | 79 | 25 | 19 | 14 | 13 | 13 |
| 22 | 30 | 22 | 30 | e18 | e10 | e6.0 | e16 | e8.8 | e6.8 | 59 | 24 | 19 | 13 | 13 | 14 |
| 23 | 32 | 26 | 37 | e17 | e10 | e5.8 | e16 | e8.4 | e7.0 | 50 | 25 | 19 | 12 | 13 | 14 |
| 24 | 35 | 25 | 38 | e17 | e10 | e5.8 | e16 | e8.4 | e7.2 | 50 | 25 | 19 | 12 | 14 | 15 |
| 25 | 40 | 24 | 37 | e17 | e10 | e5.8 | e16 | e8.2 | e7.4 | 47 | 24 | 19 | 12 | 14 | 22 |
| 26 | 38 | 22 | 35 | e17 | e10 | e5.6 | e15 | e7.8 | e7.6 | 44 | 24 | 27 | 12 | 14 | 20 |
| 27 | 41 | 21 | 33 | e16 | e10 | e5.4 | e15 | e7.4 | e7.6 | 44 | 24 | 22 | 13 | 15 | 17 |
| 28 | 39 | 21 | 31 | e16 | e11 | e5.4 | e14 | e7.4 | e7.4 | 40 | 26 | 20 | 13 | 16 | 16 |
| 29 | 36 | 21 | 30 | e15 | e11 | e5.4 | e13 | - | e7.4 | 40 | 28 | 19 | 13 | 16 | e14 |
| 30 | 33 | 20 | 29 | e15 | e11 | e5.4 | e13 | - | e7.4 | 39 | 39 | 18 | 14 | 16 | e13 |
| 31 | 30 | 20 | - | e15 | - | e5.4 | e12 | - | e7.4 | - | 32 | - | 14 | 15 | - |
| Mean | 33 | 23 | 27 | 24 | 12 | 7.4 | 9.2 | 9.6 | 7.5 | 32 | 32 | 22 | 14 | 14 | 14 |
| Max | 41 | 29 | 38 | 33 | 15 | 11 | 16 | 12 | 8.4 | 79 | 44 | 28 | 18 | 16 | 22 |
| Min | 26 | 20 | 19 | 15 | 10 | 5.4 | 4.1 | 7.4 | 6.6 | 7.6 | 24 | 18 | 12 | 12 | 13 |

Appendix A7.–Daily mean flow ($ft^3/s$) for the Meadow Creek gaging station, water year 2010 (*e* indicates estimated flow).

| Day | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 16 | 16 | e7.6 | e6.2 | e3.1 | e3.2 | e6.2 | 24 | 14 | 12 | 20 | 22 |
| 2 | 16 | 15 | e7.4 | e6.0 | e3.0 | e3.3 | e6.2 | 23 | 14 | 12 | 20 | 22 |
| 3 | 16 | e14 | e7.4 | e5.8 | e2.9 | e3.6 | e6.4 | 23 | 18 | 12 | 21 | 21 |
| 4 | 17 | e13 | e7.4 | e5.6 | e2.8 | e3.7 | e6.4 | 23 | 17 | 15 | 22 | 22 |
| 5 | 17 | e13 | e7.4 | e5.6 | e2.7 | e3.8 | e6.6 | 22 | 17 | 15 | 23 | 27 |
| 6 | 17 | e12 | e7.2 | e5.4 | e2.6 | e3.9 | e6.6 | 23 | 15 | 13 | 21 | 27 |
| 7 | 18 | e12 | e7.0 | e5.2 | e2.5 | e3.9 | e6.8 | 29 | 15 | 12 | 20 | 28 |
| 8 | 20 | e12 | e7.0 | e5.2 | e2.6 | e4.0 | e6.8 | 33 | 14 | 12 | 20 | 28 |
| 9 | 21 | e11 | e7.0 | e5.2 | e2.6 | e4.1 | e7.0 | 27 | 14 | 11 | 19 | 26 |
| 10 | 21 | e11 | e7.0 | e5.2 | e2.6 | e4.2 | e7.2 | 25 | 13 | 11 | 20 | 25 |
| 11 | 21 | e10 | e6.8 | e5.0 | e2.7 | e4.2 | e7.2 | 24 | 13 | 11 | 20 | 23 |
| 12 | 21 | e10 | e6.8 | e5.0 | e2.7 | e4.3 | e7.4 | 23 | 13 | 11 | 20 | 22 |
| 13 | 20 | e10 | e6.6 | e5.0 | e2.8 | e4.4 | e8.0 | 24 | 13 | 11 | 20 | 21 |
| 14 | 19 | e9.8 | e6.6 | e5.0 | e2.9 | e4.5 | e8.6 | 22 | 12 | 11 | 20 | 21 |
| 15 | 19 | e9.2 | e6.4 | e4.9 | e2.9 | e4.5 | e9.8 | 22 | 13 | 11 | 20 | 20 |
| 16 | 18 | e8.4 | e6.2 | e4.8 | e2.9 | e4.6 | e10 | 22 | 14 | 11 | 19 | 19 |
| 17 | 18 | e8.0 | e6.2 | e4.8 | e3.0 | e4.6 | e13 | 21 | 14 | 11 | 20 | 19 |
| 18 | 17 | e7.0 | e6.0 | e4.7 | e3.1 | e4.7 | e17 | 21 | 14 | 12 | 22 | 18 |
| 19 | 17 | e6.4 | e6.0 | e4.6 | e3.3 | e4.7 | e21 | 21 | 14 | 12 | 22 | 18 |
| 20 | 17 | e6.4 | e6.0 | e4.6 | e3.5 | e4.8 | e24 | 21 | 14 | 12 | 20 | 18 |
| 21 | 17 | e6.4 | e6.2 | e4.5 | e3.5 | e4.9 | e25 | 21 | 14 | 19 | 19 | 17 |
| 22 | 17 | e6.2 | e6.4 | e4.4 | e3.6 | e5.0 | e26 | 20 | 13 | 19 | 19 | 17 |
| 23 | 17 | e6.2 | e6.6 | e4.1 | e3.6 | e5.2 | e28 | 19 | 12 | 18 | 19 | 16 |
| 24 | 17 | e6.6 | e6.8 | e4.0 | e3.6 | e5.2 | 44 | 18 | 11 | 16 | 19 | 16 |
| 25 | 16 | e6.6 | e6.8 | e3.8 | e3.7 | e5.4 | 31 | 18 | 11 | 17 | 19 | 15 |
| 26 | 16 | e6.8 | e6.8 | e3.7 | e3.6 | e5.4 | 28 | 17 | 12 | 20 | 18 | 15 |
| 27 | 16 | e6.8 | e6.8 | e3.6 | e3.5 | e5.6 | 28 | 16 | 14 | 24 | 18 | 15 |
| 28 | 16 | e7.0 | e6.6 | e3.5 | e3.3 | e5.6 | 26 | 16 | 15 | 23 | 19 | 14 |
| 29 | 15 | e7.4 | e6.4 | e3.4 | - | e5.8 | 26 | 15 | 14 | 21 | 23 | 14 |
| 30 | 18 | e7.6 | e6.4 | e3.3 | - | e5.8 | 25 | 15 | 13 | 20 | 24 | 15 |
| 31 | 16 | - | e6.4 | e3.2 | - | e6.0 | - | 14 | - | 19 | 24 | - |
| Mean | 18 | 9.4 | 6.7 | 4.7 | 3.1 | 4.6 | 16 | 21 | 14 | 15 | 20 | 20 |
| Max | 21 | 16 | 7.6 | 6.2 | 3.7 | 6.0 | 44 | 33 | 18 | 24 | 24 | 28 |
| Min | 15 | 6.2 | 6.0 | 3.2 | 2.5 | 3.2 | 6.2 | 14 | 11 | 11 | 18 | 14 |

Appendix A8.–Daily mean flow ($ft^3/s$) for the Meadow Creek gaging station, water year 2011 (*e* indicates estimated flow).

| Day | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 17 | e13 | e10 | e8.0 | e4.5 | e2.0 | e6.0 | 28 | 16 | 12 | 10 | 19 |
| 2 | 16 | e13 | e10 | e8.0 | e4.5 | e2.0 | e7.0 | 27 | 16 | 12 | 12 | 19 |
| 3 | 16 | e13 | e10 | e8.0 | e4.5 | e2.0 | e8.0 | 26 | 16 | 12 | 13 | 19 |
| 4 | 16 | e13 | e10 | e8.0 | e4.5 | e2.0 | e9.0 | 26 | 16 | 12 | 12 | 18 |
| 5 | 16 | e12 | e9.0 | e7.0 | e4.0 | e2.0 | e11 | 27 | 17 | 11 | 15 | 18 |
| 6 | 16 | e12 | e9.0 | e7.0 | e4.0 | e2.0 | e12 | 26 | 17 | 11 | 17 | 17 |
| 7 | 16 | e12 | e9.0 | e6.0 | e4.0 | e2.0 | e13 | 25 | 18 | 11 | 20 | 16 |
| 8 | 15 | e12 | e9.0 | e6.0 | e3.0 | e2.0 | e14 | 25 | 18 | 11 | 21 | 15 |
| 9 | 15 | e12 | e9.0 | e6.0 | e3.0 | e2.0 | e15 | 25 | 17 | 10 | 26 | 15 |
| 10 | 15 | e12 | e9.0 | e5.0 | e3.0 | e2.0 | e16 | 25 | 17 | 10 | 28 | 15 |
| 11 | 15 | e12 | e9.0 | e6.0 | e3.0 | e2.0 | e17 | 24 | 17 | 10 | 27 | 14 |
| 12 | 14 | e12 | e9.0 | e6.0 | e2.0 | e2.5 | e18 | 23 | 16 | 11 | 25 | 14 |
| 13 | 14 | e12 | e9.0 | e6.0 | e2.0 | e2.5 | e19 | 22 | 16 | 11 | 24 | 14 |
| 14 | e13 | e12 | e9.0 | e5.2 | e2.5 | e2.5 | e21 | 21 | 16 | 11 | 23 | 14 |
| 15 | e13 | e12 | e8.0 | e5.0 | e2.5 | e2.5 | e22 | 20 | 17 | 11 | 22 | 14 |
| 16 | 14 | e12 | e8.0 | e5.0 | e2.0 | e2.5 | e25 | 20 | 19 | 10 | 21 | 14 |
| 17 | 14 | e11 | e8.0 | e4.0 | e2.0 | e2.5 | e27 | 19 | 19 | 10 | 21 | 14 |
| 18 | 14 | e11 | e8.0 | e3.0 | e2.5 | e2.5 | e29 | 19 | 17 | 14 | 24 | 14 |
| 19 | 14 | e11 | e8.0 | e2.5 | e2.0 | e2.5 | e37 | 19 | 16 | 13 | 24 | 13 |
| 20 | 14 | e11 | e8.0 | e3.0 | e2.0 | e2.5 | e45 | 18 | 16 | 12 | 24 | 14 |
| 21 | 14 | e11 | e8.0 | e4.0 | e2.0 | e2.5 | 47 | 18 | 16 | 11 | 22 | 13 |
| 22 | 14 | e11 | e8.0 | e4.0 | e2.0 | e2.5 | 38 | 18 | 15 | 11 | 21 | 13 |
| 23 | 14 | e11 | e8.0 | e4.0 | e1.5 | e2.5 | 33 | 18 | 15 | 11 | 20 | 14 |
| 24 | 14 | e10 | e8.0 | e4.5 | e1.5 | e2.5 | 31 | 17 | 14 | 11 | 20 | 13 |
| 25 | 14 | e10 | e8.0 | e4.5 | e1.5 | e3.0 | 31 | 17 | 14 | 11 | 19 | 13 |
| 26 | 14 | e10 | e8.0 | e4.5 | e2.0 | e4.0 | 33 | 17 | 14 | 11 | 18 | 13 |
| 27 | 13 | e10 | e7.0 | e4.5 | e2.0 | e4.0 | 36 | 16 | 13 | 11 | 18 | 13 |
| 28 | 14 | e10 | e7.0 | e4.5 | e2.0 | e5.0 | 38 | 16 | 14 | 10 | 17 | 13 |
| 29 | 14 | e10 | e7.0 | e4.5 | - | e5.0 | 30 | 16 | 13 | 10 | 17 | 13 |
| 30 | e13 | e10 | e7.0 | e4.5 | - | e5.0 | 29 | 16 | 13 | 10 | 16 | - |
| 31 | e13 | - | e7.0 | e4.5 | - | e5.5 | - | 15 | - | 10 | 17 | - |
| Mean | 15 | 11 | 8.4 | 5.2 | 2.7 | 2.8 | 24 | 21 | 16 | 11 | 20 | 15 |
| Max | 17 | 13 | 10 | 8.0 | 4.5 | 5.5 | 47 | 28.0 | 19 | 14 | 28 | 20 |
| Min | 13 | 10 | 7.0 | 2.5 | 1.5 | 2.0 | 6.0 | 15.0 | 13 | 10 | 10 | 13.0 |

Appendix A9.–Daily mean flow ($ft^3/s$) for the Meadow Creek gaging station, water year 2012 (*e* indicates estimated flow).

| Day | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 13 | e15 | e8.0 | e2.0 | e5.0 | e4.0 | e10 | 66 | 32 | 25 | e23 | 25 |
| 2 | 13 | e14 | e9.0 | e2.0 | e5.0 | e4.0 | e10 | 62 | 31 | 24 | e23 | 26 |
| 3 | 13 | e13 | e9.0 | e3.0 | e5.0 | e4.0 | e10 | 59 | 31 | 24 | e23 | 26 |
| 4 | 13 | e13 | e10 | e3.0 | e5.0 | e4.0 | e13 | 57 | 32 | e24 | e22 | 27 |
| 5 | 13 | e13 | e11 | e3.0 | e5.0 | e4.0 | e14 | 55 | 32 | e24 | e21 | 30 |
| 6 | 13 | e12 | e12 | e4.0 | e5.0 | e4.0 | e16 | 54 | 31 | e23 | e21 | 31 |
| 7 | 13 | e12 | e12 | e4.0 | e5.0 | e4.0 | e18 | 52 | 32 | e24 | 21 | 30 |
| 8 | 13 | e12 | e13 | e5.0 | e6.0 | e4.0 | e20 | 51 | 31 | e24 | 20 | 29 |
| 9 | 13 | e12 | e14 | e5.0 | e6.0 | e4.0 | e22 | 51 | 30 | e26 | 19 | 28 |
| 10 | 13 | e12 | e15 | e5.0 | e6.0 | e4.0 | e25 | 50 | 30 | e25 | 19 | 26 |
| 11 | 12 | e11 | e15 | e5.0 | e6.0 | e4.0 | e28 | 48 | 29 | e25 | 18 | 26 |
| 12 | 14 | e11 | e14 | e5.0 | e6.0 | e4.0 | e30 | 47 | 32 | e23 | 18 | 26 |
| 13 | 12 | e10 | e13 | e5.0 | e6.0 | e4.0 | e32 | 45 | 38 | e24 | 18 | 27 |
| 14 | 12 | e9.0 | e14 | e5.0 | e6.0 | e4.0 | e35 | 43 | 39 | e25 | 17 | 28 |
| 15 | 13 | e9.0 | e14 | e5.0 | e6.0 | e5.0 | e36 | 41 | 37 | e24 | 17 | 31 |
| 16 | 15 | e9.0 | e14 | e4.0 | e6.0 | e5.0 | e40 | 39 | 35 | e24 | 17 | 45 |
| 17 | 16 | e9.0 | e14 | e4.0 | e6.0 | e5.0 | e45 | 38 | 33 | e26 | 17 | 66 |
| 18 | 16 | e8.0 | e14 | e4.0 | e6.0 | e5.0 | e50 | 37 | 33 | e26 | 17 | 79 |
| 19 | 15 | e7.0 | e14 | e5.0 | e6.0 | e4.0 | e52 | 36 | 32 | e26 | 18 | 93 |
| 20 | 15 | e7.0 | e13 | e5.0 | e5.0 | e4.0 | e55 | 35 | 30 | e26 | 20 | 127 |
| 21 | 14 | e7.0 | e13 | e5.0 | e5.0 | e4.0 | e60 | 34 | 29 | e25 | 22 | 194 |
| 22 | 14 | e6.0 | e12 | e5.0 | e5.0 | e4.0 | e70 | 34 | 28 | e25 | 22 | 241 |
| 23 | 14 | e6.0 | e12 | e5.0 | e5.0 | e4.0 | e85 | 33 | 27 | e25 | 22 | 244 |
| 24 | 15 | e6.0 | e11 | e4.0 | e5.0 | e5.0 | e90 | 33 | 27 | e25 | 22 | 233 |
| 25 | 15 | e6.0 | e10 | e4.0 | e5.0 | e5.0 | 95 | 34 | 26 | e25 | 22 | 216 |
| 26 | 15 | e6.0 | e9.0 | e4.0 | e5.0 | e5.0 | 86 | 34 | 26 | e25 | 21 | 197 |
| 27 | 15 | e6.0 | e10 | e3.0 | e5.0 | e6.0 | 80 | 35 | 26 | e25 | 26 | 179 |
| 28 | e16 | e7.0 | e8.0 | e3.0 | e5.0 | e6.0 | 76 | 35 | 27 | e25 | 28 | 164 |
| 29 | e15 | e7.0 | e6.0 | e3.0 | e4.0 | e7.0 | 73 | 34 | 27 | e25 | 27 | 163 |
| 30 | e15 | e8.0 | e4.0 | e4.0 | - | e8.0 | 69 | 33 | 26 | e25 | 25 | 160 |
| 31 | e14 | - | e3.0 | e5.0 | - | e9.0 | - | 32 | - | e24 | 25 | - |
| Mean | 14 | 9.4 | 11 | 4.1 | 5.4 | 4.7 | 45 | 43 | 31 | 25 | 21 | 94 |
| Max | 16 | 15 | 15 | 5.0 | 6.0 | 9.0 | 95 | 66 | 39 | 26 | 28 | 244 |
| Min | 12 | 6.0 | 3.0 | 2.0 | 4.0 | 4.0 | 10.0 | 32.0 | 26 | 23 | 17 | 25 |

Appendix A10.–Daily mean flow ($ft^3/s$) for the Meadow Creek gaging station, water year 2013 (*e* indicates estimated flow).

| Day | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 149 | e30 | e17 | e22 | e13 | e15 | e12 | 107 | 74 | 36 | 21 | 31 |
| 2 | 138 | e32 | e15 | e22 | e11 | e17 | e13 | 104 | 72 | 37 | 21 | 33 |
| 3 | 129 | e32 | e12 | e22 | e11 | e18 | e14 | 105 | 79 | 34 | 21 | 37 |
| 4 | 129 | e32 | e12 | e17 | e11 | e20 | e14 | 112 | 78 | 33 | 21 | 42 |
| 5 | 129 | e30 | e12 | e17 | e12 | e20 | e12 | 125 | 74 | 33 | 21 | 50 |
| 6 | 154 | e38 | e14 | e17 | e12 | e20 | e13 | 124 | 83 | 33 | 21 | 52 |
| 7 | 180 | e34 | e13 | e17 | e14 | e21 | e16 | 114 | 74 | 32 | 22 | 54 |
| 8 | 183 | e34 | e13 | e12 | e14 | e22 | e15 | 101 | 67 | 32 | 23 | 55 |
| 9 | 177 | e34 | e15 | e12 | e17 | e22 | e15 | 99 | 67 | 32 | 24 | 55 |
| 10 | 167 | e34 | e17 | e12 | e19 | e23 | e15 | 96 | 64 | 32 | 26 | 54 |
| 11 | 156 | e38 | e20 | e12 | e22 | e20 | e15 | 104 | 63 | 31 | 28 | 62 |
| 12 | 146 | e38 | e23 | e12 | e21 | e20 | e19 | 106 | 63 | 30 | 31 | 80 |
| 13 | 136 | e38 | e24 | e9.0 | e23 | e20 | e20 | 105 | 60 | 29 | 30 | 87 |
| 14 | 128 | e38 | e24 | e12 | e26 | e18 | e20 | 100 | 59 | 29 | 28 | 83 |
| 15 | 123 | e38 | e25 | e9.0 | e25 | e17 | e25 | 92 | 57 | 29 | 27 | 76 |
| 16 | 117 | e34 | e26 | e13 | e24 | e18 | e30 | 86 | 51 | 29 | 26 | 70 |
| 17 | 110 | e36 | e25 | e8.0 | e21 | e15 | e32 | 88 | 52 | 29 | 26 | 66 |
| 18 | 100 | e36 | e25 | e10 | e21 | e15 | e40 | 101 | 47 | 30 | 27 | 62 |
| 19 | 103 | e36 | e25 | e10 | e19 | e14 | e51 | 99 | 46 | 30 | 29 | 63 |
| 20 | 103 | e30 | e26 | e9.0 | e18 | e14 | e54 | 94 | 45 | 30 | 32 | 64 |
| 21 | 95 | e30 | e26 | e9.0 | e17 | e12 | e65 | 91 | 39 | 29 | 35 | 61 |
| 22 | 94 | e29 | e23 | e9.0 | e17 | e12 | e87 | 87 | 36 | 29 | 41 | 58 |
| 23 | 90 | e20 | e21 | e9.0 | e17 | e11 | e115 | 84 | 35 | 28 | 47 | 54 |
| 24 | 75 | e21 | e21 | e12 | e15 | e11 | e145 | 80 | 35 | 28 | 49 | 51 |
| 25 | e65 | e17 | e23 | e10 | e15 | e11 | e200 | 74 | 34 | 29 | 43 | 56 |
| 26 | e60 | e17 | e23 | e8.0 | e15 | e10 | e225 | 71 | 33 | 29 | 35 | 71 |
| 27 | e52 | e17 | e23 | e8.0 | e12 | e10 | 179 | 68 | 33 | 28 | 32 | 80 |
| 28 | e49 | e17 | e23 | e8.0 | e12 | e10 | 176 | 67 | 33 | 26 | 30 | 79 |
| 29 | e42 | e17 | e23 | e8.0 | - | e12 | 146 | 67 | 33 | 25 | 32 | 73 |
| 30 | e35 | e17 | e25 | e10 | - | e12 | 119 | 65 | 32 | 24 | 31 | 68 |
| 31 | e30 | - | e25 | e10 | - | e12 | - | 70 | - | 22 | 30 | - |
| Mean | 111 | 30 | 21 | 12 | 17 | 16 | 63 | 93 | 54 | 30 | 29 | 61 |
| Max | 183 | 38 | 26 | 22 | 26 | 23 | 225 | 125 | 83 | 37 | 49 | 87 |
| Min | 30 | 17 | 12 | 8 | 11 | 10 | 12 | 65 | 32 | 22 | 21 | 31 |

# APPENDIX B. SIMPLE LINEAR REGRESSION RESULTS FOR COMPUTING THE DAILY MEAN FLOW RECORD FOR THE FISH AND MEADOW CREEK DISCHARGE STATIONS

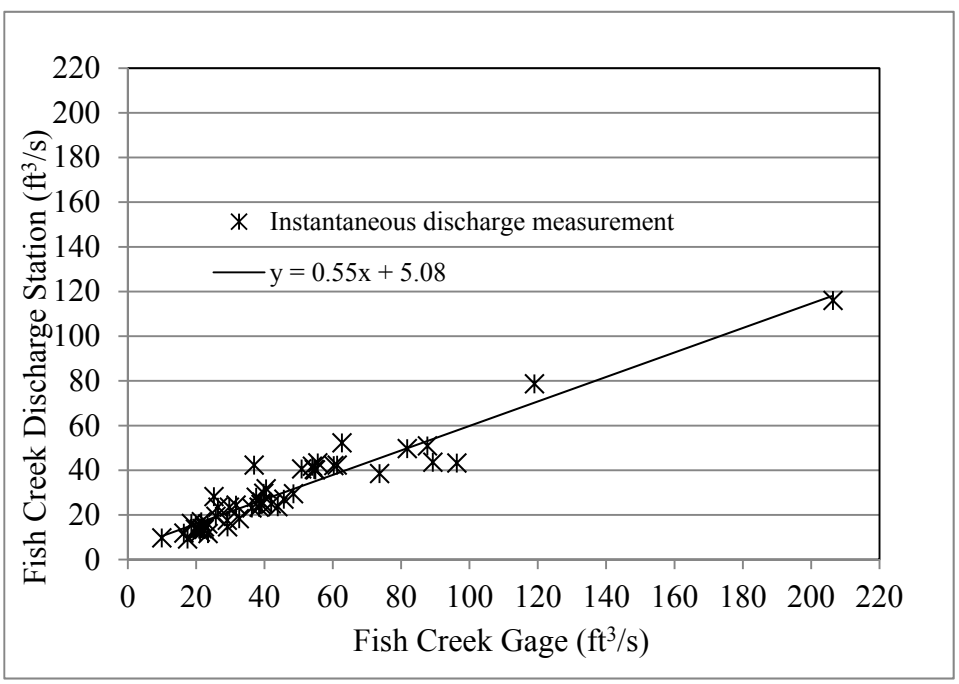
Appendix B1.–Simple linear regression results for computing the daily mean flow record for the Fish Creek discharge station.

| Regression Statistics | |
|---|---|
| Multiple R | 0.95 |
| R Square | 0.91 |
| Adjusted R Square | 0.91 |
| Standard Error | 5.86 |
| Observations | 48 |

ANOVA

| | *df* | *SS* | *MS* | *F* | Significance *F* |
|---|---|---|---|---|---|
| Regression | 1 | 15675.38 | 15675.38 | 456.06 | 0.00 |
| Residual | 46 | 1581.08 | 34.37 | | |
| Total | 47 | 17256.46 | | | |

| | Coefficients | Standard Error | *t* Stat | *P*-value | Lower 95% | Upper 95% |
|---|---|---|---|---|---|---|
| Intercept | 5.08 | 1.44 | 3.52 | 0.00 | 2.17 | 7.98 |
| X Variable 1 | 0.55 | 0.03 | 21.36 | 0.00 | 0.50 | 0.60 |



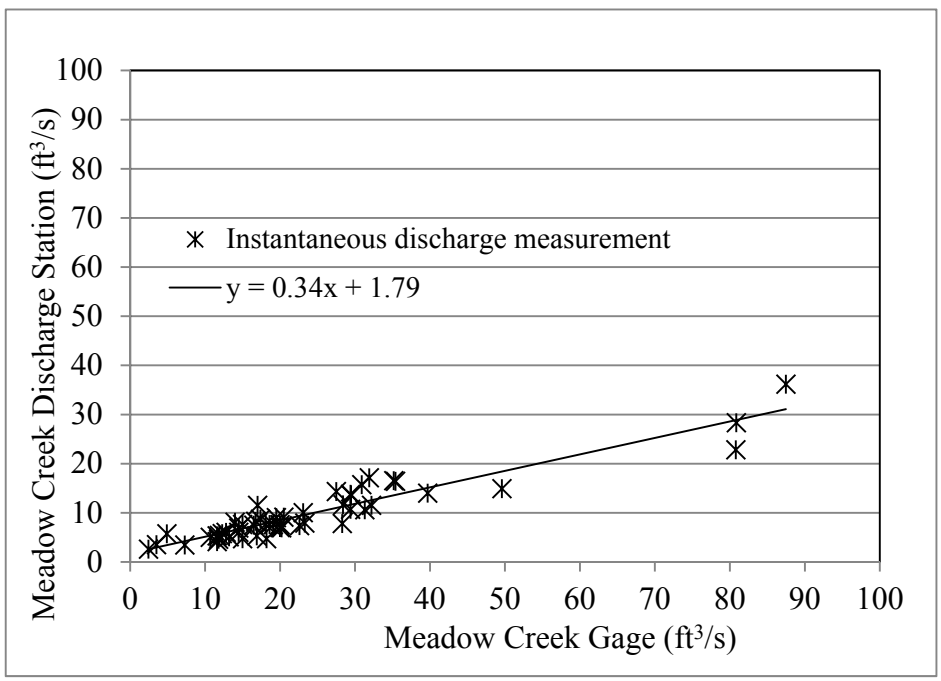
Appendix B2.–Simple linear regression results for computing the daily mean flow record for the Meadow Creek discharge station.

| Regression Statistics | |
|---|---|
| Multiple R | 0.94 |
| R Square | 0.88 |
| Adjusted R Square | 0.88 |
| Standard Error | 2.16 |
| Observations | 52 |

ANOVA

| | *df* | *SS* | *MS* | *F* | Significance *F* |
|---|---|---|---|---|---|
| Regression | 1.00 | 1754.15 | 1754.15 | 377.21 | 0.00 |
| Residual | 50.00 | 232.51 | 4.65 | | |
| Total | 51.00 | 1986.67 | | | |

| | Coefficients | Standard Error | *t* Stat | *P*-value | Lower 95% | Upper 95% |
|---|---|---|---|---|---|---|
| Intercept | 1.79 | 0.51 | 3.50 | 0.00 | 0.76 | 2.82 |
| X Variable 1 | 0.34 | 0.02 | 19.42 | 0.00 | 0.30 | 0.37 |



# APPENDIX C. ADF&G GAGING AND DISCHARGE STATION AVAILABLE DATA

Appendix C1.–The following data used for this report are stored in the WISKI database and are available upon request.

| Data series name | Description |
|---|---|
| Fish Creek gaging station #12001: | |
| Q.DayMean.E | Available daily mean flows from 16 July 2008 to 30 September 2013 |
| Q.Obs.Q | Instantaneous measured discharge collected from 16 July 2008 to 30 September 2013 |
| WT.Water Temp.1 | Water temperature at 15-min intervals from 16 July 2008 to 30 September 2013 (data gaps during winter) |
| Station Description | Summary of gage location, equipment, benchmarks, access, and other interesting details |
| Station Analysis | Summary gage operation and streamflow computations, ratings, etc. for all water years |
| Fish Creek discharge station #12002: | |
| Q.DayMean.E | Available daily mean flows from 16 July 2008 to 30 September 2013 |
| Meadow Creek gaging station #12101: | |
| Q.DayMean.E | Available daily mean flows from 16 July 2008 to 30 September 2013 |
| Q.Obs.Q | Instantaneous measured discharge collected from 16 July 2008 to 30 September 2013 |
| WT.Water Temp.1 | Water temperature at 15 min intervals from 16 July 2008 to 30 September 2013 (data gaps during winter) |
| Station Description | Summary of gage location, equipment, benchmarks, access, and other interesting details |
| Station Analysis | Summary gage operation and streamflow computations, ratings, etc. for all water years |
| Meadow Creek discharge station #12102: | |
| Q.DayMean.E | Available daily mean flows from 16 July 2008 to 30 September 2013 |

*Note:* These files are stored in the WISKI database server. To access, contact ADF&G Division of Sport Fish, Research and Technical Services, 333 Raspberry Rd, Anchorage, AK 99518.

# APPENDIX D. PHOTOGRAPHS OF FISH AND MEADOW CREEK GAGING AND DISCHARGE STATIONS

Appendix D1.–View of Fish Creek gaging station in foreground looking downstream on 1 May 2012. Discharge was measured at 206 $ft^3/s$.

Appendix D2.–Measuring stream discharge at the Fish Creek discharge station on 11 September 2008. Discharge was measured at 27 $ft^3/s$.

Appendix D3.–Measuring stream discharge at the Meadow Creek gaging station on 24 July 2008. Discharge was measured at 32 $ft^3/s$.

Appendix D4.–Measuring stream discharge at the Meadow Creek discharge station on 3 August 2012. Discharge was measured at 10 $ft^3/s$.