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# FISHERIES INVESTIGATION ADDENDUM STUDY REPORT

**Final**

**LAKE CHELAN HYDROELECTRIC PROJECT  
FERC Project No. 637**

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*Prepared by:*  
**Duke Engineering & Services, Inc.  
Bellingham, Washington**

*Prepared for:*  
**Public Utility District No. 1 of Chelan County  
Wenatchee, Washington**

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## **SECTION 1: INTRODUCTION**

The 1999 Lake Chelan Tributary Investigations (DE&S 2000a) determined that alluvial fans exposed by lake drawdown developed barriers to upstream fish migration in six of the nine study tributaries. Annual drawdown of Lake Chelan is a normal part of the operations of the Lake Chelan Hydroelectric Project (Project). The barriers were due to excessive gradient, excessive water velocity, or insufficient water depth in the drawdown zone. As the lake level rises, the barriers become inundated and upstream passage becomes unimpeded. To determine whether the barriers are exposed during the time when adfluvial rainbow and cutthroat trout (*Onchorhynchus mykiss* and *O. clarki*) attempt to migrate upstream, spawning timing in each of the tributaries was assessed.

The objectives of this study were to:

1. Determine spawning timing of rainbow and cutthroat trout in the study tributaries.
2. Determine temperature regimes in the study tributaries.
3. Determine stage and discharge regimes in the study tributaries.
4. Determine relative and absolute abundance of fish species within the Project limits (1/4 mile upstream of the mouth) of the study tributaries.
5. Determine fish utilization of the habitat at the mouth and in the study tributaries within the Chelan Project limits.

The period of study was from April 4 through September 29, 2000 in the following nine study tributaries:

First Creek	Mitchell Creek	Gold Creek
Twenty-five Mile Creek	Grade Creek	Safety Harbor Creek
Prince Creek	Rail Road Creek	Fish Creek

In addition, Blackberry Creek and Company Creek, tributaries to the Stehekin River, were added to this study in May 2000 for the purpose of determining spawning timing in these two creeks.

The goal of this study was to establish baseline information concerning the timing of spawning and fry emergence in the study tributaries to Lake Chelan. This information was then used to evaluate the probable effects of Project operations and lake level fluctuations on the alluvial fans in the drawdown zone, and tributary-spawning adfluvial rainbow and cutthroat trout.

### Assumptions

Spawning timing in the study tributaries was estimated based on the timing of initial sightings of fry emergence in the creeks. Estimating spawning timing based on the observation of emergent trout fry requires a number of assumptions.

- Adfluvial and resident trout exhibit similar spawning timing; that is, rainbow and cutthroat trout will have the same spawning timing whether they are resident of the tributaries or migrate to the tributaries from Lake Chelan.
- Trout fry of 30 mm or less emerged from the gravel within 24 hours of observation.
- Rainbow and cutthroat trout egg development both require similar incubation periods and temperature regimes.
- The incubation period, from spawning to emergence, is dependent on water temperature and is equal to a determined number of temperature units above freezing.

### 1.1 Temperature Units

Trout egg development is primarily dependent on water temperature. By recording the water temperature during the incubation period, the date of spawning, or emergence can be estimated if the date of one event is known. Water temperature, however, is highly variable so average daily temperatures are used in this calculation. Each degree centigrade of the daily average water temperature is one temperature unit, or Daily Temperature Unit (DTU). The average incubation temperature also plays a role; development is slightly delayed at lower temperatures and accelerated at higher temperature (ADF&G 1983). Table 1-1 lists the number of temperature units required for development at three incubation temperatures.

**Table 1-1.** Daily Temperature Units required from spawning to emergence for rainbow trout (Piper et al. 1982, Senn et al. 1984).

Average Incubation Temperature $\pm 2.5^{\circ}$	Daily Temperature Units Required
7.2°C (45°F)	572 C (1029 F)
10.0°C (50°F)	535 C (963 F)
12.8°C (55°F)	532 C (957 F)

## **SECTION 2: METHODS**

### **2.1 Hydrology**

Stream discharge in each of the nine lake tributaries was estimated by recording the water surface elevation and applying this to a stage-discharge rating curve that was calculated from discharge measurements taken over the study period. The water surface elevation was recorded with Solinst leveloggers (models 3001 and LT 3001) that were hung inside a 2 inch galvanized pipe, or stilling well. The pipe was perforated at about 6-inch intervals along its length and was secured upright in the stream channel. Stilling wells were located where the water surface elevation would reflect the discharge but not be subject to vandalism and excessive turbulence. These instruments record the water plus air pressure above the instrument sensor. Barometric pressure was recorded at the Twenty-five Mile Creek gage and subtracted from the recorded water pressure data to calculate the height of the water column above the instrument. Water depth was related to the staff gage attached to the side of the stilling well and applied to the rating curve to calculate the stream discharge. At least seven discharge measurements were taken of each creek ranging from low flow to high flow conditions. Flows were measured with a Swoffer propeller-type current meter. The high flow of Railroad Creek was measured from the bridge using a bridgeboard with a Price AA current meter.

### **2.2 Temperature**

Water temperature was recorded with Onset Optic Stowaway thermologgers or by Solinst levelogger instruments (model LT 3001) at 15 minute intervals for the period of April 5 through September 27. The water temperature of Blackberry and Company creeks was recorded for the period of May 21 through September 27. Minimum, maximum and mean temperature for each day was calculated from the data.

### **2.3 Electrofishing**

Electrofishing was conducted in four of the Lake Chelan tributaries. Water temperature, flow, or turbidity prevented conducting this survey in the remaining creeks. This effort was conducted using the same parameters as the electrofishing study that was conducted in October 1999 (DE&S 2000a). A Smith Root model 12A Programmable Output Wave (POW) battery powered backpack electrofisher was used to capture fish in a 100-m study reach. Output of the electrofisher was set at the same settings reported in the previous study. Block nets were set upstream and downstream of the study reaches to prevent the loss of fish from the study reach. If the creek temperature was below 4°C, flows too high, or turbidity inhibited the capture of fish, electrofishing was postponed.

### **2.4 Snorkeling**

Snorkeling surveys were conducted at the mouths of each of the nine Lake Chelan tributaries and upstream for a distance of at least 100 m. The snorkeling surveys began in early April and continued through mid-July and were conducted at two-week intervals. The purpose of the snorkeling surveys was to document the presence and utilization of the creeks by adfluvial fish. In Blackberry and Company creeks, snorkeling was conducted over a length of at least 100 m, but did not necessarily include the confluence of creek with the Stehekin River. These surveys were conducted in

Blackberry and Company creeks from May 21 through July 19. Trout greater than 305 mm (12 in.) were assumed to be adfluvial fish and those less than 305 mm were assumed to be resident fish.

### **2.5 Emergent Fry**

Emergent fry surveys were conducted from July 5 through September 28 in the nine Lake Chelan tributaries from the mouth for a distance of at least 100 m. Additional observations were made near the staff gage and discharge measurement stations. Biologists walked up the study streams and visually searched the stream margins and pools for trout fry. The fry were captured with aquarium nets and placed in a clear plastic bag filled with water for identification and length measurements. On each visit, several fry were captured to provide data of relative species abundance and size ranges, but not to provide data to quantify species population.

In Blackberry Creek the emergent trout surveys were conducted from the location of the thermologger, about 300 m upstream of the confluence with the Stehekin River, upstream at least 100 m. In Company Creek the surveys were conducted from the confluence with the Stehekin River to at least 100 m upstream in both forks of the creek.

### **2.6 Spawning Timing**

Determination of spawning timing was calculated using daily temperature units (DTUs). Emergent trout fry less than 30 mm (fork tail length) were assumed to have emerged from the gravel on the day prior to observation. The sum of the DTU from the day of emergence back to the day of spawning was calculated. In streams where the incubation temperature ranged substantially over two incubation regimes, a range of spawning timing was estimated.

## **SECTION 3: SPAWNING HABITAT REQUIREMENTS**

### **3.1 Hydrology**

The maximum discharge and high flow period varied in each creek. The high flow periods of the down-lake creeks, First, Mitchell, Gold, Grade, Twenty-five Mile, and Safety Harbor creeks began in early to mid-April and continued through May and into June. High flows in the three up-lake creeks, Prince, Railroad, and Fish creeks began in mid-May and continued through June. The high flow of Railroad Creek continued to mid-July. The baseflow for each creek was estimated from the average daily discharge from the end of the high flow period to the end of the study period. This estimate is likely an overestimate because it does not include the month of October when the discharge in each creek would likely remain low. Table 3-1 lists the maximum discharge and estimated baseflow and dates of occurrence for each of the study creeks, including the Stehekin River. Figure 3-1 shows the period of the spring high flows with a comparison to the Stehekin River for the same period. Hydrographs for each creek and the Stehekin River are attached in Appendix A. The Hydrographs of the three uplake creeks correlated very closely with the Stehekin River. The peak flows shown on each of hydrographs occur on the same days. The hydrographs on the downlake creeks do not correlate well with each other or with the Stehekin River. Though the spring high flow is apparent on the hydrographs, the scale and duration of the high flows differ with each system. Confidence is high for the hydrology data with the exception of the high flow data in Safety Harbor Creek. During the high flows in Safety Harbor Creek, water crested over a boulder above the gage, which created excessive turbulence at the gage location.

### **3.2 Temperature**

The average daily temperature of each of the creeks was between 3°C and 6°C in early April and steadily increased to a maximum average daily temperature on July 31 in each of the creeks. Minimum and maximum average daily temperatures varied with each creek and are listed in Table 3-2. The maximum water temperature was coincidentally recorded on July 31 in all of the creeks, except for Twenty-five Mile Creek where the maximum temperature was recorded on August 5. Thermographs for each stream are attached in Appendix B.

### **3.3 Electrofishing**

Electrofishing was conducted in four of the nine Lake Chelan tributaries. The number of fish captured was far less than the number captured in the October 1999 study. This may have been partially due to poor conditions for electrofishing. Water temperatures in the creeks were low and fish were not active. During the electrofishing study, several fish were observed escaping into the interstitial spaces of the substrate where they could not be captured. Table 3-3 compares the results from the April 2000 study with the October 1999 study. Because the capture rate was low and electrofishing conditions were poor, the April 2000 data were not used to estimate fish population statistics. Electrofishing was attempted in again in May 2000 but high flow and turbidity in the creeks made conditions poor and unsafe for electrofishing. Of interest, an adfluvial rainbow trout measuring 510 mm was captured in First Creek on April 4.

### **3.4 Snorkeling Surveys**

Resident trout were observed in all of the study creeks and adfluvial trout were observed in First, Grade, Twenty-five, Safety Harbor, Prince and Railroad creeks. Adfluvial trout were not observed in Mitchell, Gold, Fish or Blackberry creeks. Table 3-4 and Table 3-5 lists the observations made for each creek. Adfluvial suckers (*Catostomus* spp.) were also observed congregating at the creek mouths and migrating upstream during these surveys, but adfluvial trout were observed at the creek mouths only after upstream passage was accessible. Many of the suckers were observed with spawning coloration and the number of suckers in the creeks far outnumbered the trout.

### **3.5 Emergent Fry**

Emergent trout fry were first observed in Gold Creek on July 6 and in First Creek on July 7 during the snorkeling surveys. Two weeks later, on July 19 emergent fry were observed in Safety Harbor and Prince creeks and two weeks following emergent fry were observed in Mitchell, Fish, Blackberry and Company Creeks. Emergent trout were observed in Railroad Creek on August 20, but were not observed on any of the surveys in Grade or in Twenty-five Mile creeks. Table 3-6 lists the observations of emergent fry. A total of 123 emergent fry were positively identified and of these, only five were cutthroat trout (4% of the total). Fourteen emergent fry could not be positively identified. These fish could have been rainbow/cutthroat hybrids or the distinguishing features were not pronounced enough for accurate identification.

### **3.6 Spawning Timing**

Trout spawning in First Creek was estimated to begin in early May. By mid-May spawning was occurring in Gold, Safety Harbor, and Prince creeks. In the tributaries to the Stehekin River, spawning was estimated to begin in late May. In Railroad Creek, spawning did not appear to occur until early July. Table 3-7 lists the estimated spawning dates for the study streams with daily average water temperature and average incubation temperature.

**Table 3-1.** Maximum discharge and estimated baseflow for April 4 through September 28, 2000

CREEK	MAXIMUM PEAK FLOW (cfs)	DATE	BASEFLOW (cfs)	DATE
First	97.8	April 14	7.6	May 15 – Sept 28
Mitchell	6.5	April 31	1.8	May 15 – Sept 28
Gold	11.1	April 20	0.7	June 1 – Sept 28
Grade	35.8	April 22	2.6	July 1 – Sept 28
Twenty-five Mile	145	May 23	8.5	July 1 – Sept 28
Safety Harbor	141 <sup>1</sup>	June 8	5.3	July 1 – Sept 28
Prince	531	June 18	26.1	July 1 – Sept 28
Railroad	1,284	June 15	153	Aug 1 – Sept 28
Fish	526	June 21	24.6	July 1 – Sept 28
Stehekin River <sup>2</sup>	6,010	May 22	1,130	Aug 1 – Sept 28

1. Low confidence; gage location was subject to excessive turbulence during high flows.
2. USGS year 2000 provisional data

CREEK	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
First	■	■				
Mitchell	■	■				
Gold	■	■				
Grade		■	■			
Twenty-five Mile	■	■	■			
Safety Harbor		■	■			
Prince			■	■		
Railroad			■	■	■	
Fish			■	■		
Stehekin River <sup>1</sup>			■	■	■	

1. USGS year 2000 provisional data

**Figure 3-1.** Period and duration of spring high flows for April 1 through September 28, 2000

**Table 3-2.** Minimum and maximum average daily temperature and maximum instantaneous temperature for period of April 4 through September 29, 2000.

CREEK	APRIL 5	JULY 31	MAX TEMP <sup>1</sup>
First	5.4°	11.4°	13.3°
Mitchell	5.3°	16.2°	19.4°
Gold	4.8°	16.9°	19.7°
Grade	4.5°	16.2°	18.4°
Twenty-five Mile	4.4°	14.3°	16.2° <sup>2</sup>
Safety Harbor	4.5°	17.7°	20.4°
Railroad	3.9°	14.2°	16.2°
Prince	3.5°	16.2°	18.4°
Fish	4.2°	14.7°	16.5°
Blackberry <sup>3</sup>	5.5° <sup>4</sup>	11.4°	13.2°
Company <sup>3</sup>	5.3° <sup>4</sup>	11.4°	12.9°

1. Measured on July 31 in all creeks except Twenty-five Mile Creek.
2. Maximum temperature recorded on August 5.
3. Temperature recorded from May 22 through September 27.
4. Temperature recorded on May 25.

**Table 3-3.** Results of electrofishing in the Lake Chelan study tributaries.

CREEK	APRIL 2000	OCTOBER 1999	COMMENTS
First	26	49	8°C
Mitchell	25	111	9°C
Gold		49	4°C
Grade	30	91	6°C
Twenty-five Mile		82	5°C
Safety Harbor		74	3°C
Railroad			High flow and turbid
Prince		71	3°C
Fish	18	31	4°C, High velocity

**Table 3-4.** Adult fish observed during snorkeling surveys in all study tributaries (April – May).

CREEK	April 4	April 25	May 8	May 22
First	1 ARB		4 ARB, 5 RRB	1 ARB, 2 RRB
Mitchell			2 SUM	6 SUM
Gold				50 SUM
Grade				36 SUM, 1RRB
Twenty-five Mile				2 SUM, 6 SUU
Safety Harbor				Note 1
Railroad	Note 1	Note 1	Note 1	Note 1
Prince			5 ARB, 1 ACT 40 RRB, 4 RCT	Note 1
Fish				Note 1
Blackberry				Note 1
Company				1 ARB/CT

**Table 3-5.** Adult fish observed during snorkeling in all study tributaries (June – July 19).

CREEK	June 7	June 20	July 5	July 19
First	6 RRB, 3 SUM	4 ARB, 29 RRB 1 RCT		
Mitchell	60 SUM, 1 RRB	16 RRB		
Gold	30 SUM, 2 SUU	6 RRB, 13 SUU	5 RRB, 30 SUM	
Grade	20 SUM, 2 RRB	1 ACT, 1 RRB 38 SUU	10 RRB, 5 SUU 15 SUM	
Twenty-five Mile	100 SUM, >50 SUU	15 ARB, 12 RRB >80 SUU	1 ARB, 13 RRB 30 SUM, 30 SUU	
Safety Harbor	3 ARB, 6 RRB, 20 SUM, 15 SUU	1ACT, 1 RRB 18 SUU	6 ARB, 16 RRB 15 SUM	21 RRB 2 SUM, 16 SUU
Prince	Note 1	3 ARB, >25 SUM	7 ARB, 10 RRB 6 ACT, 8 RCT 35 SUM, 20 SUU	>20 RRB/CT
Railroad	Note 1	4 RRB, 6 SUM	9 RRB, 4RCT 8 SUU	2 ACT, 20 RRB/CT 1SUU, 2 SUM
Fish	Note 1	1 RRB	9 RRB	10 RRB/CT
Blackberry	Note 1	Note 1		1 RRB
Company	Note 1	Note 1		1RRB

1. Tributary discharge too high to safely snorkel.

**Key:** ARB Adfluvial rainbow >305 mm (12 in.)  
 RRB Resident rainbow < 305 mm (12 in.)  
 ACT Adfluvial cutthroat > 305 mm (12 in.)  
 RCT Resident cutthroat < 305 mm (12 in.)  
 SUM Sucker observed at mouth of tributary.  
 SUU Sucker observed upstream of tributary mouth.

**Table 3-6.** Emergent trout fry and kokanee adults observed during emergent fry surveys.

CREEK	July 6	July 19	August 2	August 20	September 14*	September 28
First	9 ERB		21 ERB	7 ERB 1 ERB/CT 13 Etrout		
Mitchell			3 ERB	2 Etrout		
Gold	6 ERB		7 ERB			
Grade						
Twenty-five Mile						5 adult kokanee
Safety Harbor		10 ERB	15 ERB	5 ERB, 1 ERB/CT 15 Etrout sp.		
Prince		2 ERB	4 ERB, 2 ECT 7 ERB/CT	5 ERB, 1 ECT 24 Etrout sp.		1 ERB 6 Etrout
Railroad				2 ERB, 4 ERB/CT	1 ERB, 1 ERB/CT 2 Etrout sp.	3 adult kokanee
Fish			2 ERB		2 ERB, 3 Etrout sp.	8 adult kokanee
Blackberry			1 ECT, 9 Etrout	5 ERB, 2 ERB/CT		5 Etrout Thousands of kokanee
Company			7 ERB, 1 ECT 15 Etrout	4 ERB, 4 ERB/CT many Etrout 7 adult kokanee		10 Etrout Hundreds of kokanee

\* Observations made in Railroad and Fish creeks only.

**Key:** ERB Emergent rainbow fry ~ 30 mm  
 ECT Emergent cutthroat fry ~ 30 mm  
 Etrout Emergent trout fry observed but not captured

**Table 3-7.** Estimated spawning dates for trout in Lake Chelan study tributaries.

CREEK	EMERGENT FRY OBSERVED	SPECIES	ESTIMATED SPAWNING DATE	AVERAGE SPAWNING TEMP (°C)	AVERAGE INCUBATION TEMP (°C)
First	July 7	Rainbow	April 30 – May 5	7.5°	8.9°
	July 19		May 22	8.4°	9.2°
	August 2		June 10	8.5°	9.8°
	August 20		June 29	10.1°	9.8°
Mitchell	August 20	Rainbow	June 24	12.5°	13.4°
Gold	August 12	Rainbow	May 18	9.1°	10.8°
	August 3		June 25	12.1°	13.7°
Grade	No emergent fry observed				
Twenty-five Mile	No emergent fry observed				
Safety Harbor	August 2 August 20	Rainbow	May 17 - May 21	7.8°	8.9°
			June 15 – June 19	8.4°	11.8°
			July 14 – July 17	12.2°	15.2°
Prince	July 19	Rainbow and Cutthroat	May 16 – May 20	7.7°	8.9°
	August 2		June 16	8.1°	11.7°
	August 20		July 10	11.1°	13.3°
	September 27		August 12	13.0°	11.7°
Railroad	August 20	Rainbow and Cutthroat	July 5	8.5°	11.7°
	September 14		July 30	13.1°	11.1°
Fish	August 2	Rainbow	June 3	7.0°	9.4°
	September 14		July 29	12.7°	11.7°
Blackberry	August 2	Rainbow and Cutthroat	May 22 – May 27	6.1°	8.3°
	August 20		June 24	8.0°	9.4°
	September 27		August 1	10.6°	9.4°
Company	August 2	Rainbow and Cutthroat	May 22 – May 27	5.8°	7.8°
	August 20		June 24	7.8°	8.9°
	September 27		August 1	10.4°	9.4°

## **SECTION 4: DISCUSSION**

Rainbow and cutthroat trout spawning is stimulated by raising water temperatures and typically occurs between 5° - 9°C (Behnke 1992, Brown and Mackay 1995). Spawning in the study streams was estimated to occur when temperatures ranged from 5.8°C in Company Creek to 12.5°C in Mitchell Creek. Spawning was estimated as early as May 1 in First Creek and as late as July 30 in Railroad Creek (Table 3-7). Barriers to upstream migration and species interaction may be partial causes to the wide range of spawning temperature and timing.

Historically, the Lake Chelan population of native cutthroat trout began spawning in early May and continued through June. The Stehekin Hatchery operated from 1916 through 1927 and would harvest eggs from the spawning cutthroat trout from the last week of April through June 20 (CCPUD 1967). With the exception of Mitchell and Railroad creeks, spawning timing for the year 2000 was estimated to occur within this period (Table 3-7). It is assumed that both resident and adfluvial trout will spawn during the same period and the estimated spawning dates were based on observations of emergent fry that could have been progeny of either population. Figure 4-1 shows the estimated spawning timing of trout in each of the study streams and for suckers based on the emergent fry study and snorkeling survey.

Adfluvial trout were observed in First and Prince creeks prior to the high-flow spring freshets and during the high flow period in Safety Harbor Creek. But, it was not until after the high flows had abated that adfluvial trout gained access to Grade, Twenty-five Mile and Railroad creeks. Gradient barriers to upstream passage were likely present in Grade and Safety Harbor Creeks. Twenty-five Mile and Railroad creeks may have had velocity barriers due to the high discharges.

Suckers were observed in Twenty-five mile creek on May 22 (Table 3-4) when the average daily water temperature was 7.4°C and trout should have also been able to enter the creek. Table 8 shows the estimated date, lake elevation and stream temperature when upstream passage was accessible to adfluvial trout. This table is based on actual observations of adfluvial trout in the study streams made during the snorkeling surveys and assumes that the fish had migrated upstream within three days prior to observation. Table 4-1 provides the estimated date when barriers in the draw down zone were inundated and passage was accessible to adfluvial trout. For each creek, the average daily temperature is provided on the day passage was estimated to have become accessible.

Passage may have been available in Railroad Creek earlier than shown in Table 4-1, but because flows were too high to safely snorkel, observations could not be made. However, the estimated spawning timing began on July 5 (Table 3-7), which also suggests that a barrier to upstream passage did likely exist until the high flows had eased and/or high pool elevation was achieved.

Later access to the spawning habitat forces the adfluvial trout to compete with the suckers that appear to spawn in June and July. Suckers spawn in late spring and summer and broadcast their spawn over gravel and sand (Wydoski and Whitney 1979). The strong tail action of the spawning suckers may disrupt the trout redds and directly harm the eggs laying in the gravel. Also, the large

numbers of adult suckers in the creeks compete for holding and resting stations in the creek and may push the trout into less suitable habitat and thereby cause the trout to expend more energy to reach their spawning ground. Sucker fry emerge in about two weeks and feed on the same items as the emergent trout fry. Trout fry that emerge later in the summer likely have the disadvantage of reduced food sources and consequently lower survival rates.

Adfluvial trout were not observed holding at the creek mouths prior to migrating upstream until after passage was available. During the surveys when adfluvial trout were observed upstream of the creek mouths they were also observed at the creek mouths as well. Suckers were however, often found congregating at the creek mouths in great numbers (Table 3-4 and Table 3-5). The behavior of the suckers included feeding and preparation for spawning. Many of the male suckers were observed in spawning coloration at the creek mouths. On June 6, at the mouth of Mitchell Creek the substrate in the lake near the creek mouth was disturbed in patches as if spawning activity had been occurring. Mitchell Creek spreads over the alluvial fan at the mouth creating a depth barrier to upstream passage for adfluvial trout and suckers. This barrier is not inundated until the lake is near full pool elevation. But even after passage was accessible, neither adfluvial trout nor suckers were observed upstream of the creek mouth.

CREEK	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
First						
Mitchell						
Gold						
Grade						
Twenty-five Mile						
Safety Harbor						
Prince						
Railroad						
Fish						
Blackberry						
Company						
Suckers						

**Figure 4-1.** Estimated trout spawning period for each creek based on emergent fry observations. Sucker spawning period is based on observation of fish upstream of the creek mouths.

**Table 4-1.** Estimated date of upstream passage, average daily temperature, and lake elevation.

CREEK	APRIL 1	MAY 5	MAY 22	JUNE 4	JUNE 17	JULY 16
First	6.3°					
Mitchell	No adfluvial trout observed					
Gold	No adfluvial trout observed					
Grade					10.7°	
Twenty-five Mile					9.7°	
Safety Harbor				8.9°		
Prince		5.6°				
Railroad						10.7°
Fish	No adfluvial trout observed					
Blackberry	No adfluvial trout observed					
Company			5.7°			
Lake Elevation (ft MSL)	1087.8	1089.8	1091.6	1093.9	1097.3	1099.6

## ***SECTION 5: CONCLUSIONS***

Spawning timing of adfluvial trout in the tributaries to Lake Chelan appears to be regulated by both temperature and the ability of the fish to migrate upstream. Rising temperatures trigger spawning activity in the spring (Behnke 1992) but barriers to upstream migration prevent the adfluvial trout from entering the creeks until the rising lake level inundates the barriers. Water velocity barriers due to high discharges from snowmelt may also impede the upstream migration of adfluvial trout. If adfluvial trout were able to migrate upstream prior to the high flow period, then the trout spawning period in each creek would presumably occur in May and June. This would reduce competition with suckers for spawning habitat and may provide a competitive advantage to trout fry for food items. Earlier access to spawning streams may result in a higher natural production of trout.

The alluvial fans in the drawdown zone are dynamic, and barriers to upstream migration would change from year to year. For example, in 1999 a barrier was identified at the mouth of Prince Creek at lake levels below elevation 1,092 ft (DE&S 2000a) but in this study passage was accessible around 1089.8 ft (Table 4-1). Project operations may be altered to expose the drawdown zone earlier in the fall to allow fall and winter storms to cut a channel through the alluvial deposits. In addition, raising the lake earlier in the spring may inundate barriers in the drawdown zone. However, fall and winter storms are infrequent (DE&S 2000b) and passage channels may need to be excavated if they are not cut naturally. It is recommended that each creek should be surveyed for upstream passage barriers in March of each year, and if barriers are identified, then establishing a passage channel should be undertaken. Table 3-1 provides discharge data that can be used as design parameters for excavating the passage channels.

## ***SECTION 6: LITERATURE CITED***

- Behnke, R. J. 1992. Native trout of western North America. Fisheries Society Monograph 6.
- Brown, R. S. and W. C. Mackay. 1995. Spawning ecology of cutthroat trout (*Oncorhynchus clarki*) in the Ram River, Alberta. Can. J. Fish. Aquat. Sci. 52. 983-992.
- CCPUD. 1967. Overview of Lake Chelan fishery problems. PUD No. 1 of Chelan County. Wenatchee, WA.
- DE&S. 2000a. Lake Chelan fisheries investigations. Prepared by Duke Engineering & Services for PUD No. 1 of Chelan County, Wenatchee WA.
- DE&S. 2000b. Tributary barrier analysis. Prepared by Duke Engineering & Services for PUD No. 1 of Chelan County, Wenatchee WA.
- Wydoski, Richard S. and Richard R. Whitney. 1979. Inland Fishes of Washington. University of Washington Press.

***APPENDIX A: HYDROGRAPHS OF AVERAGE DAILY DISCHARGE  
AND INSTANTANEOUS DISCHARGE MEASUREMENTS***

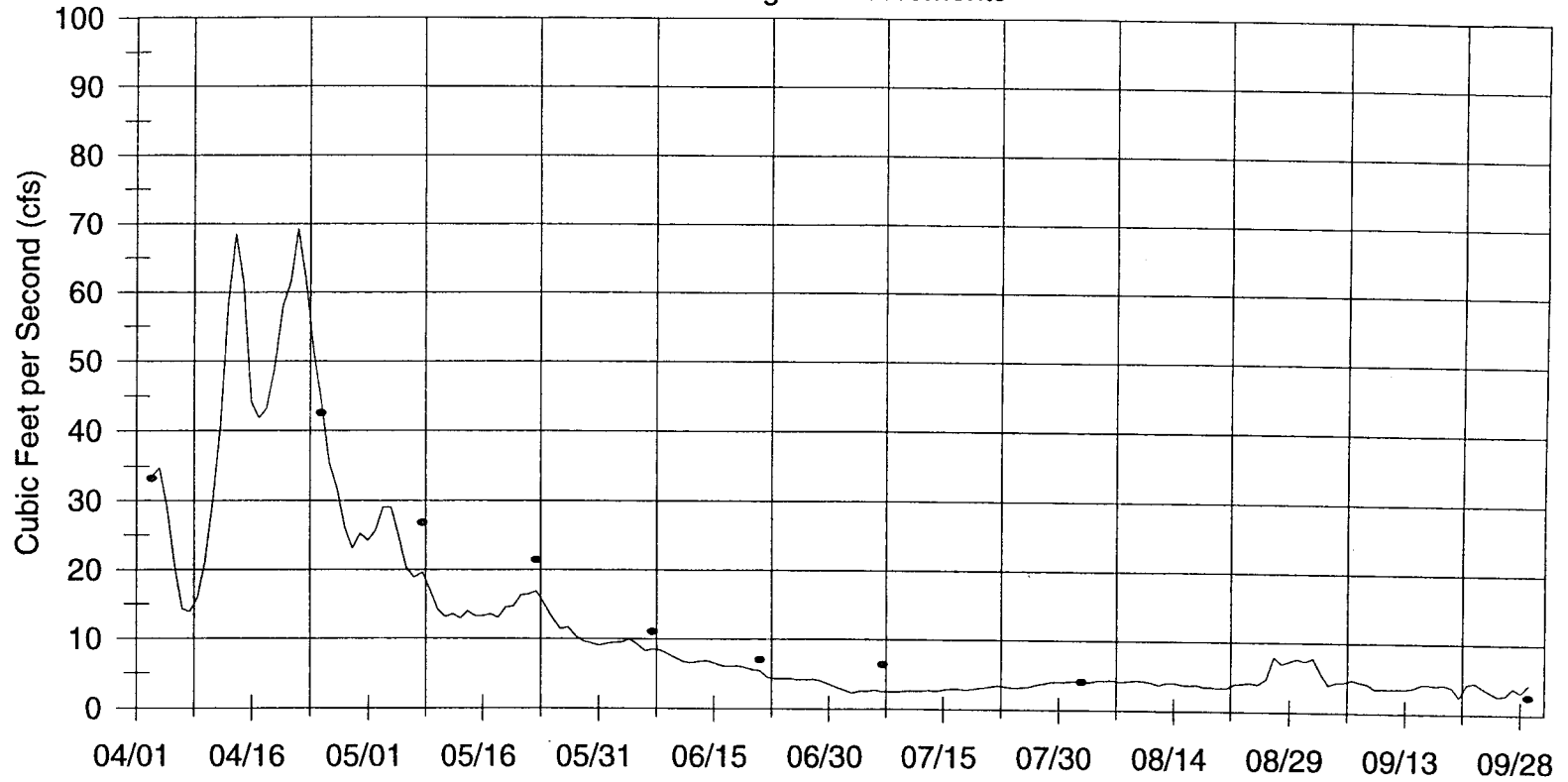
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# First Creek

## Average Daily Discharge

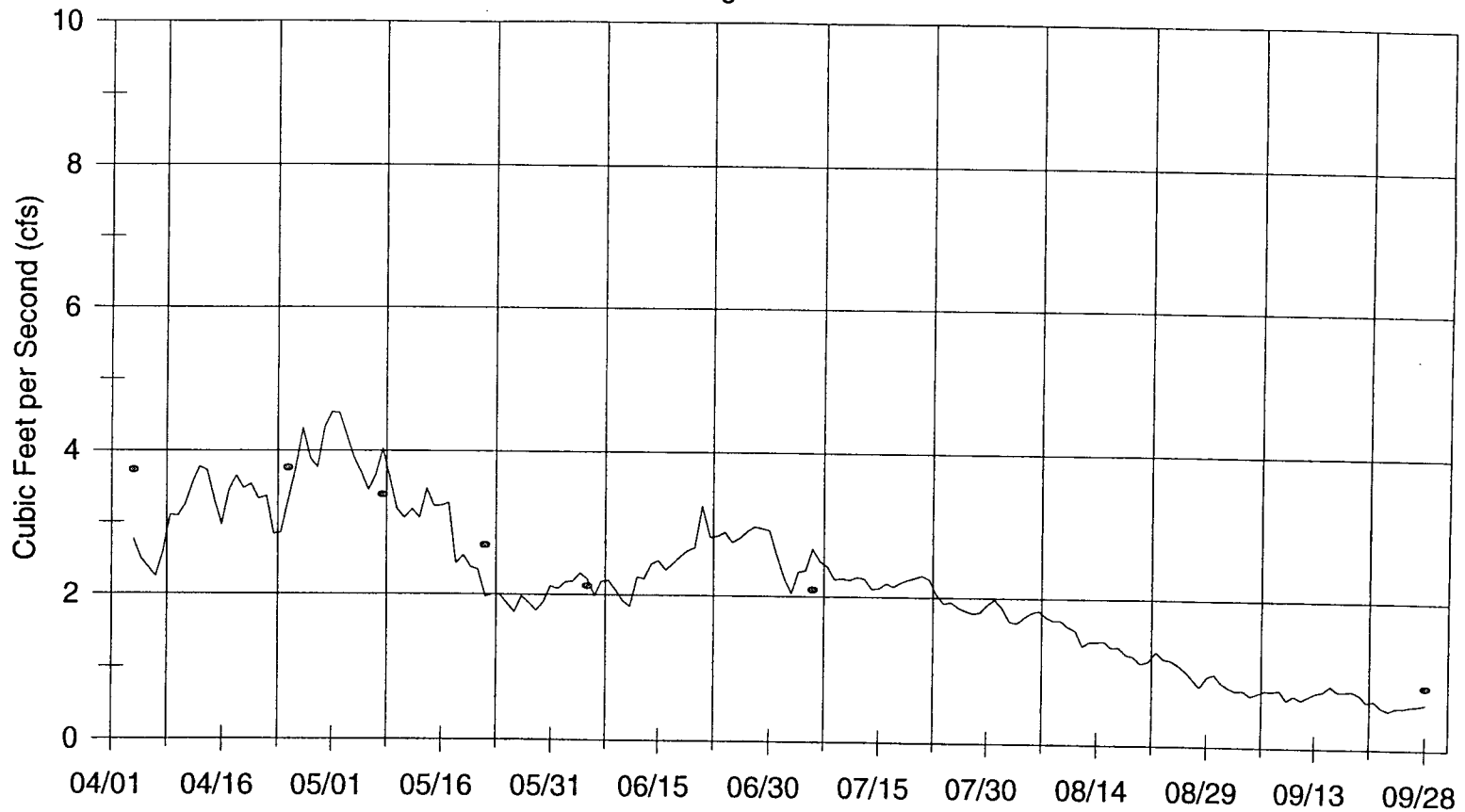
• Discharge Measurements



# Mitchell Creek

## Average Daily Discharge

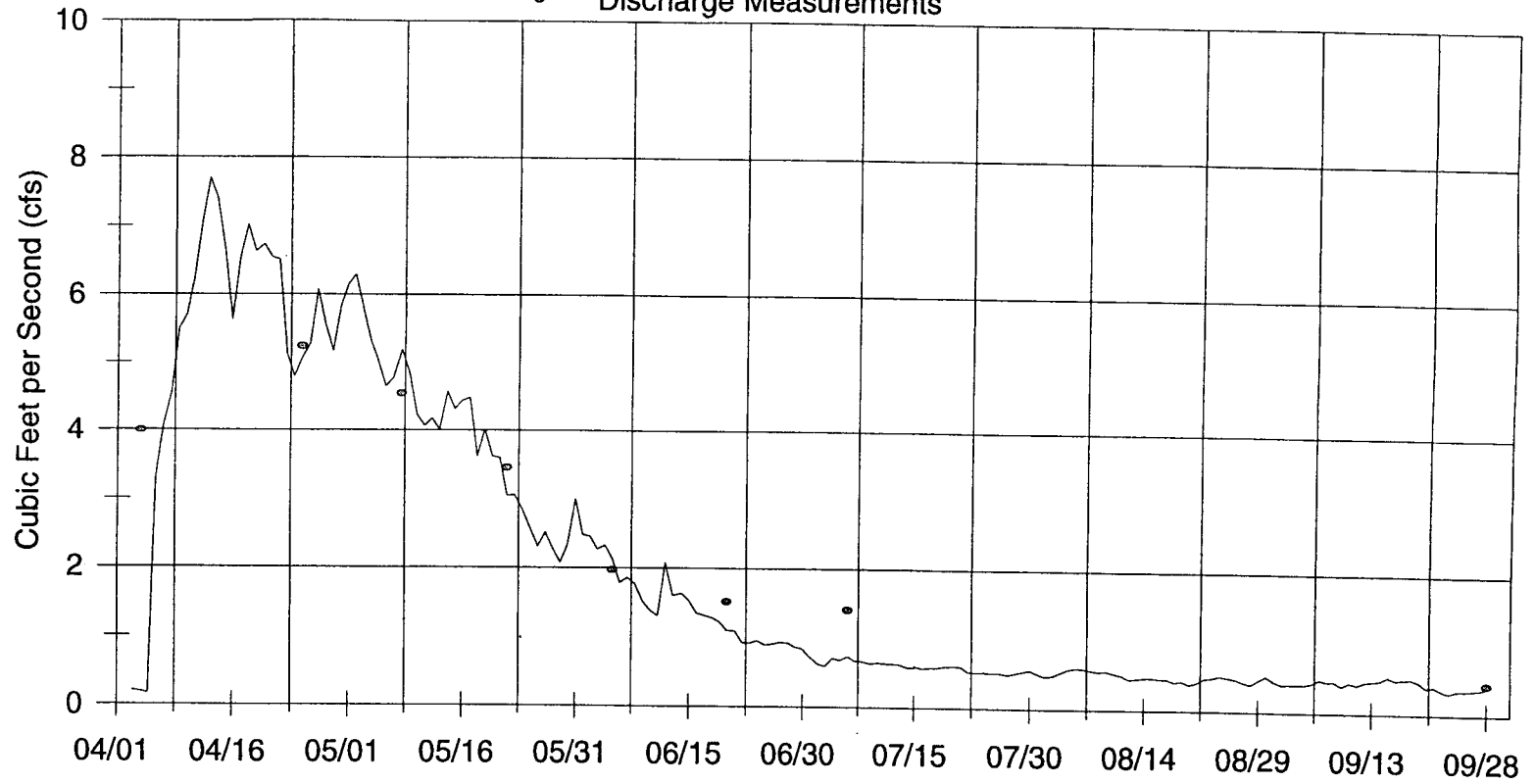
• Discharge Measurements



# Gold Creek

## Average Daily Discharge

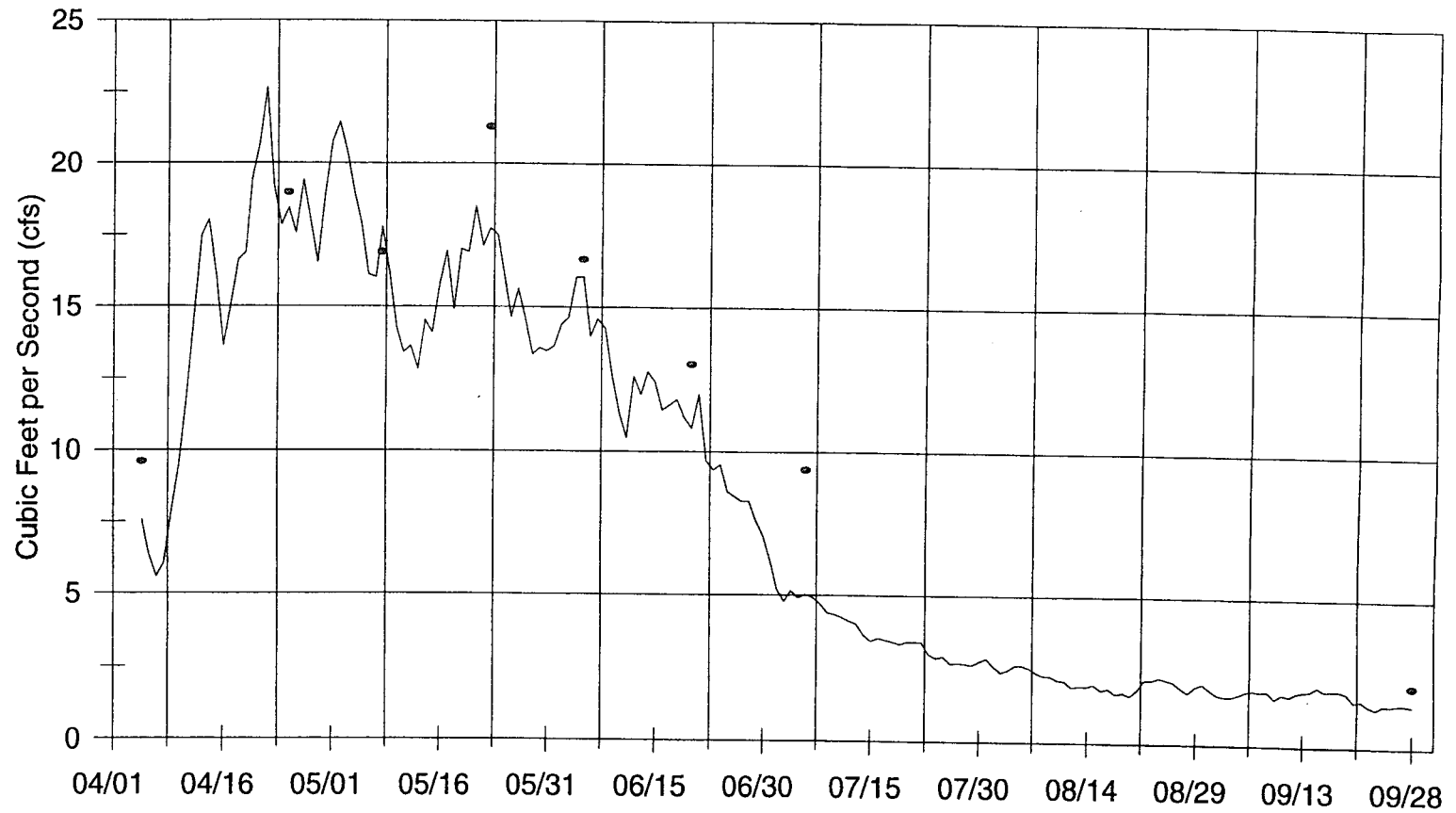
• Discharge Measurements



# Grade Creek

## Average Daily Discharge

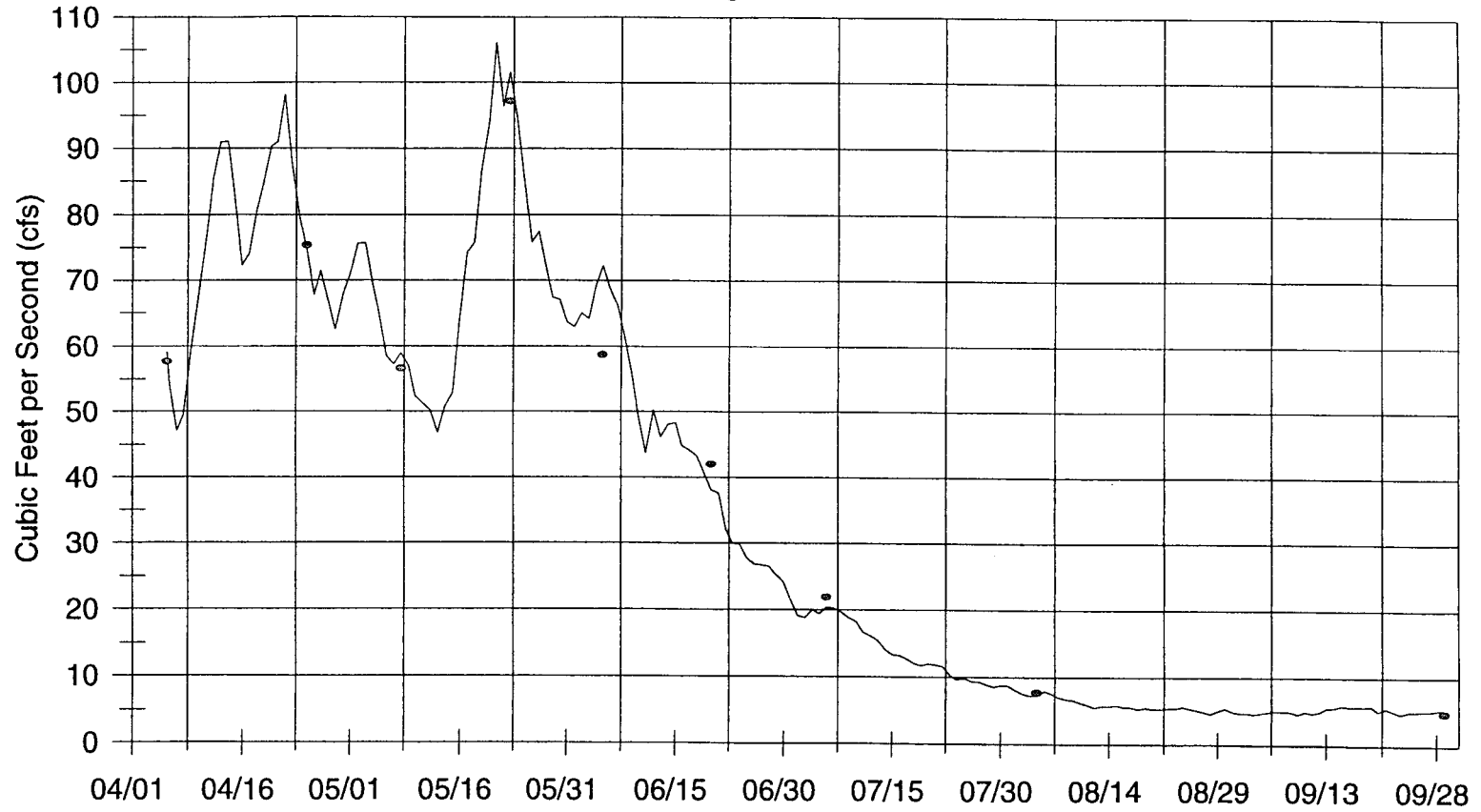
• Discharge Measurements



# Twenty-five Mile Creek

## Average Daily Discharge

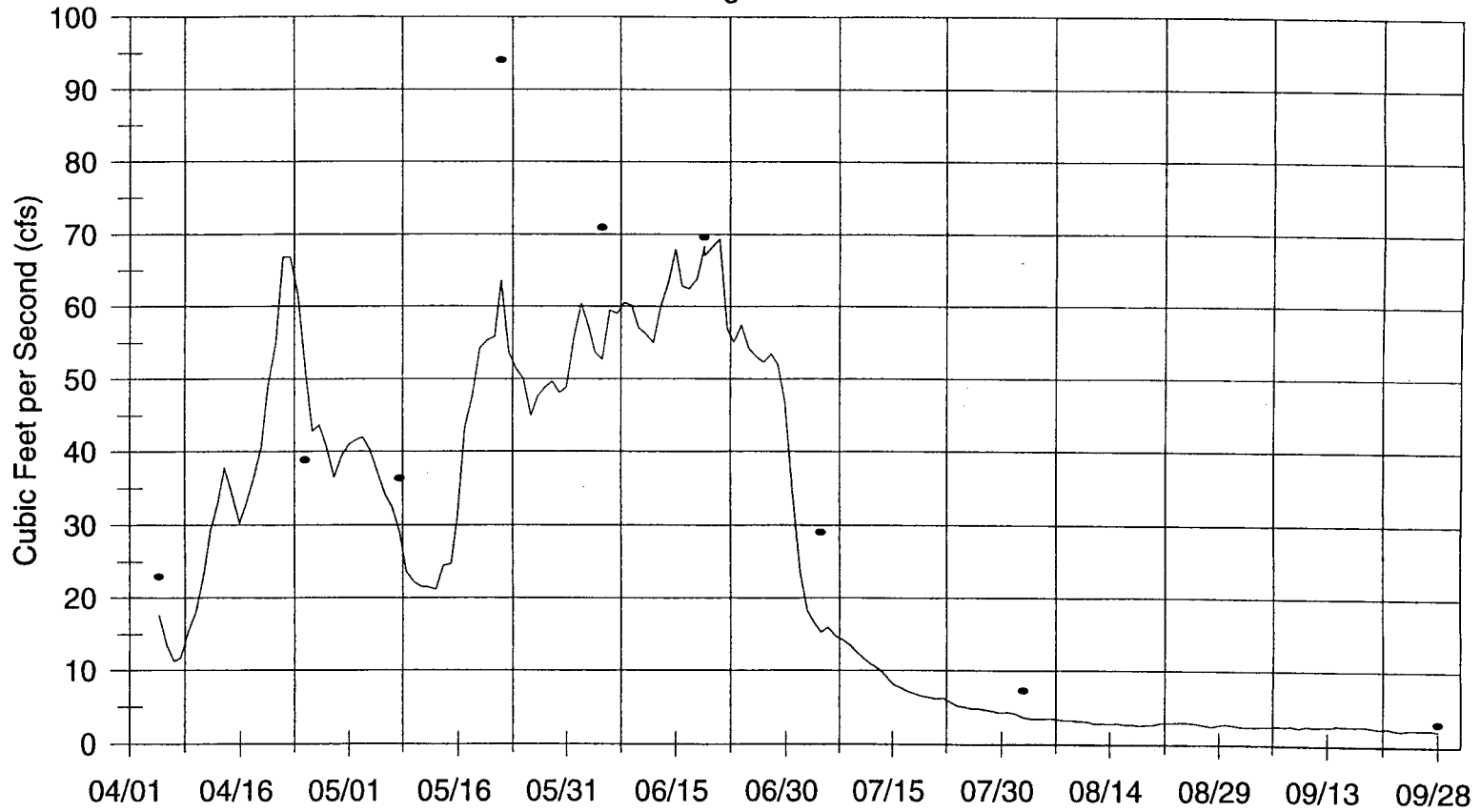
• Discharge Measurements



# Safety Harbor Creek

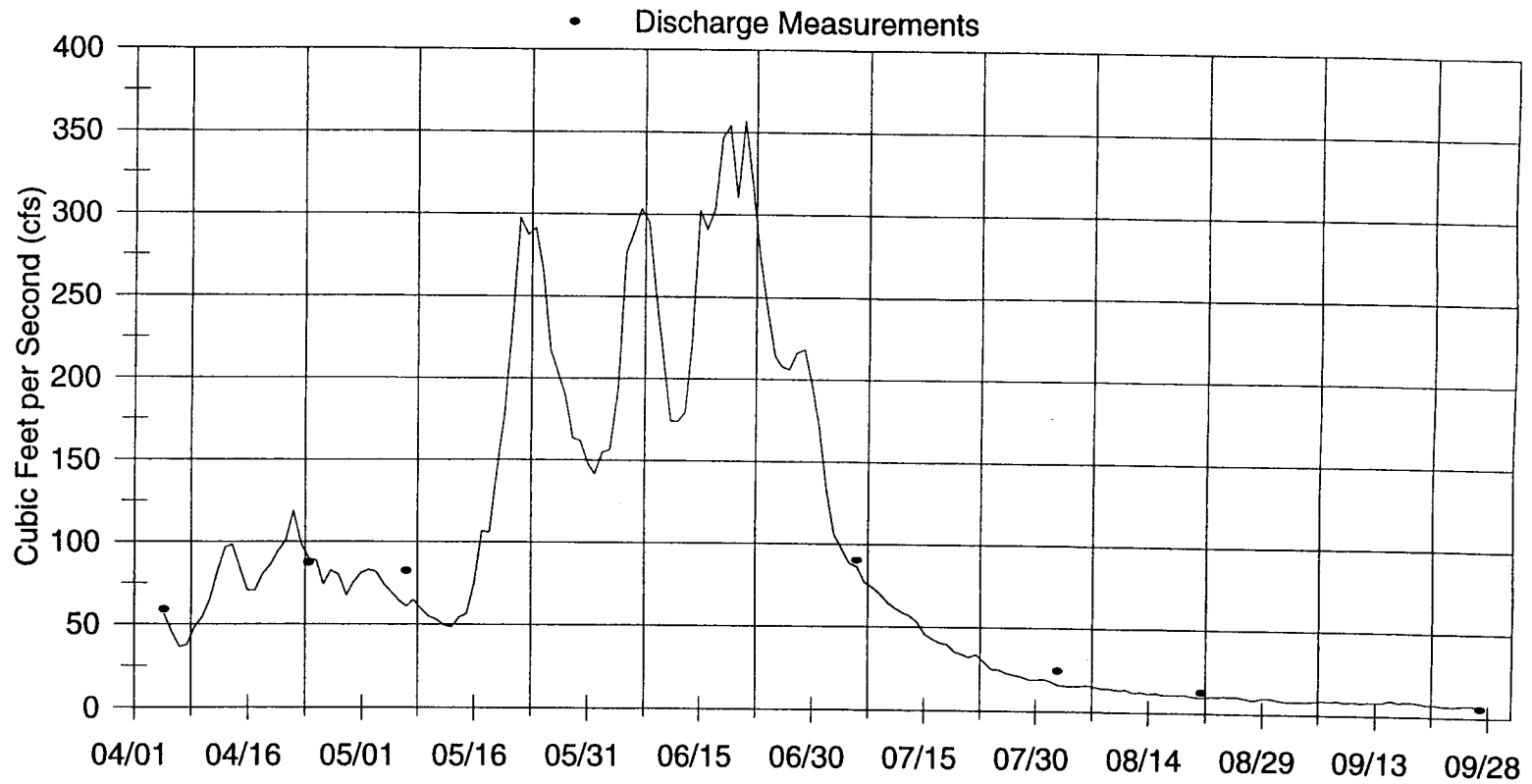
## Average Daily Discharge

• Discharge Measurements



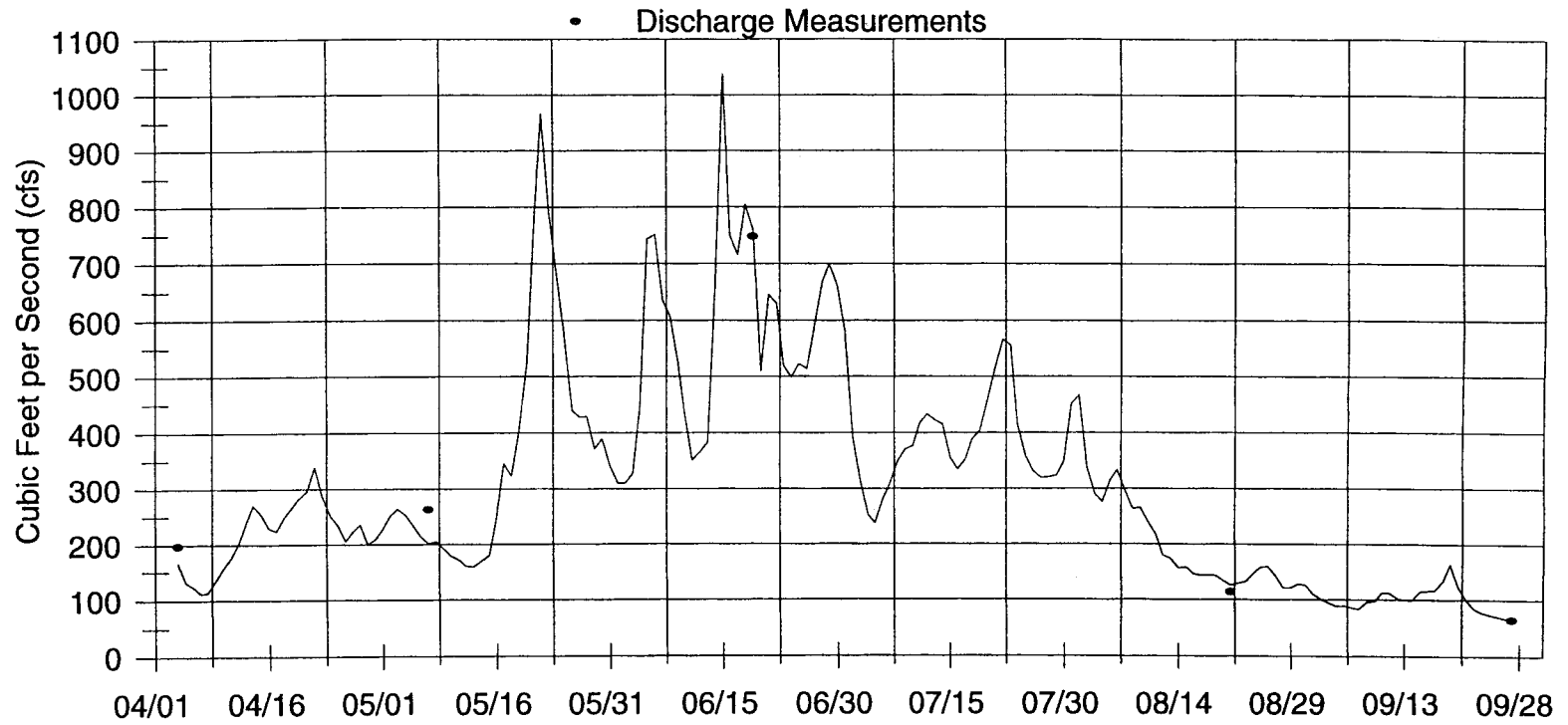
# Prince Creek

## Average Daily Discharge



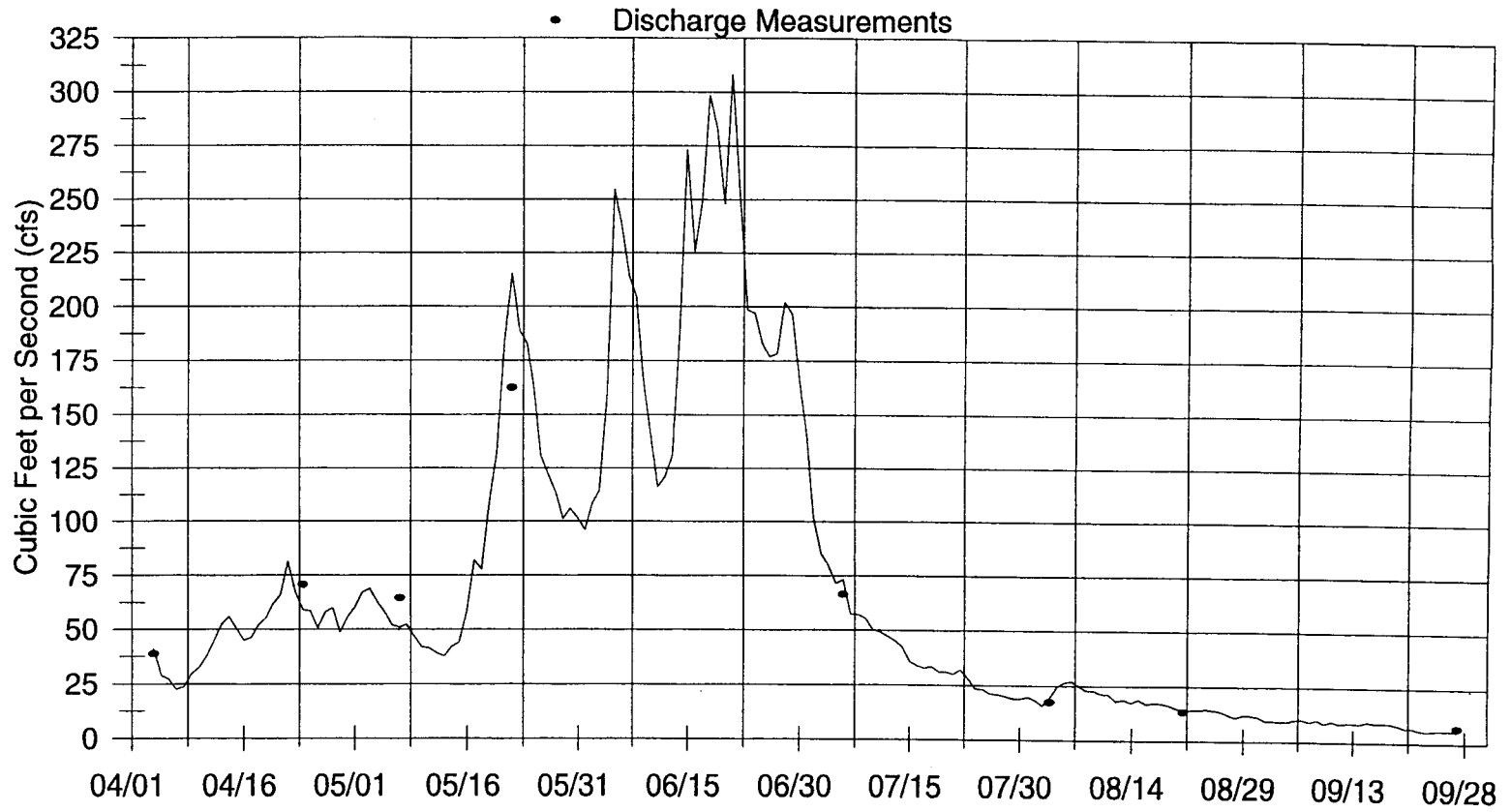
# Railroad Creek

## Average Daily Discharge



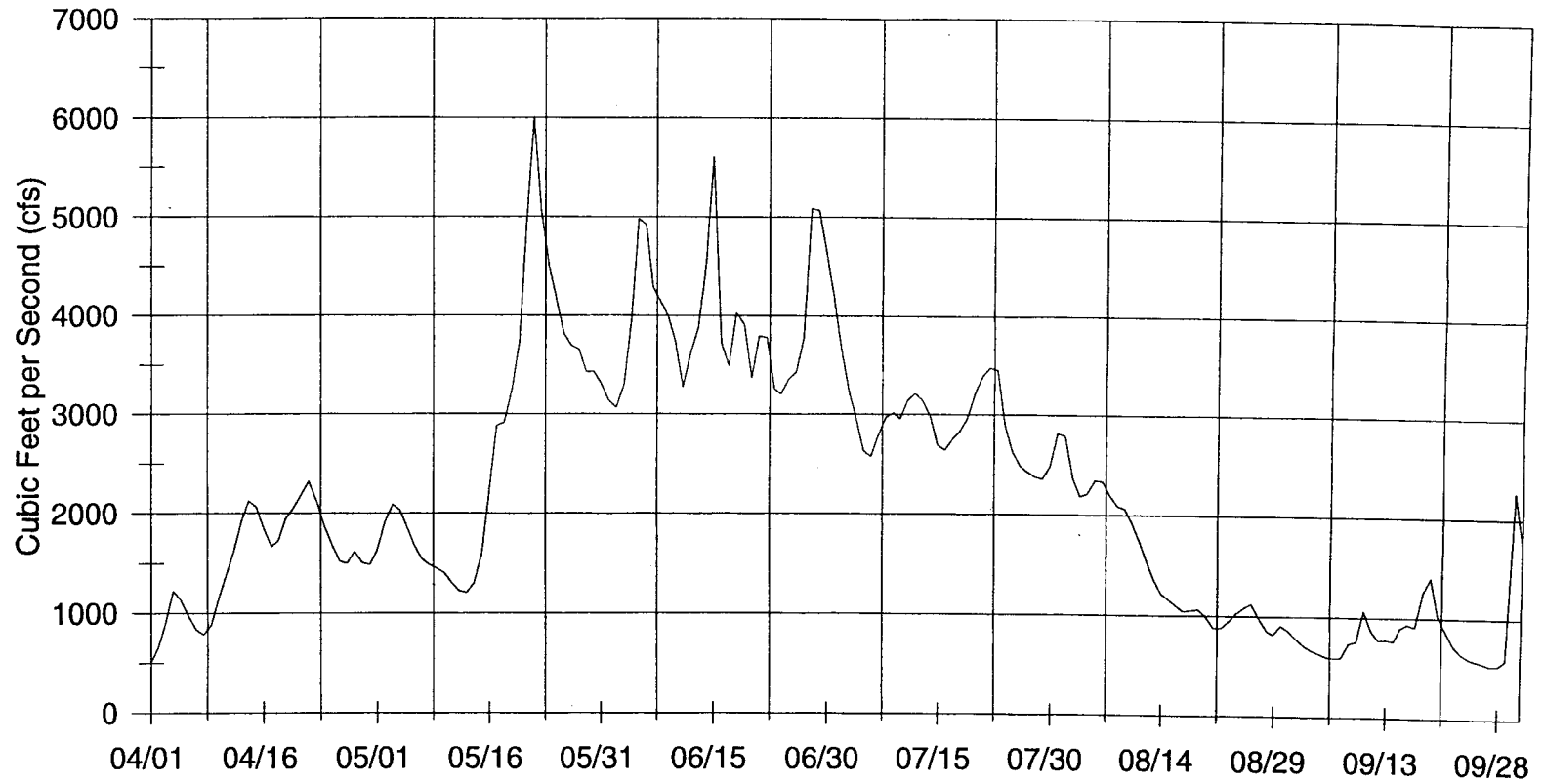
# Fish Creek

## Average Daily Discharge



# Stehekin River

## Average Daily Discharge



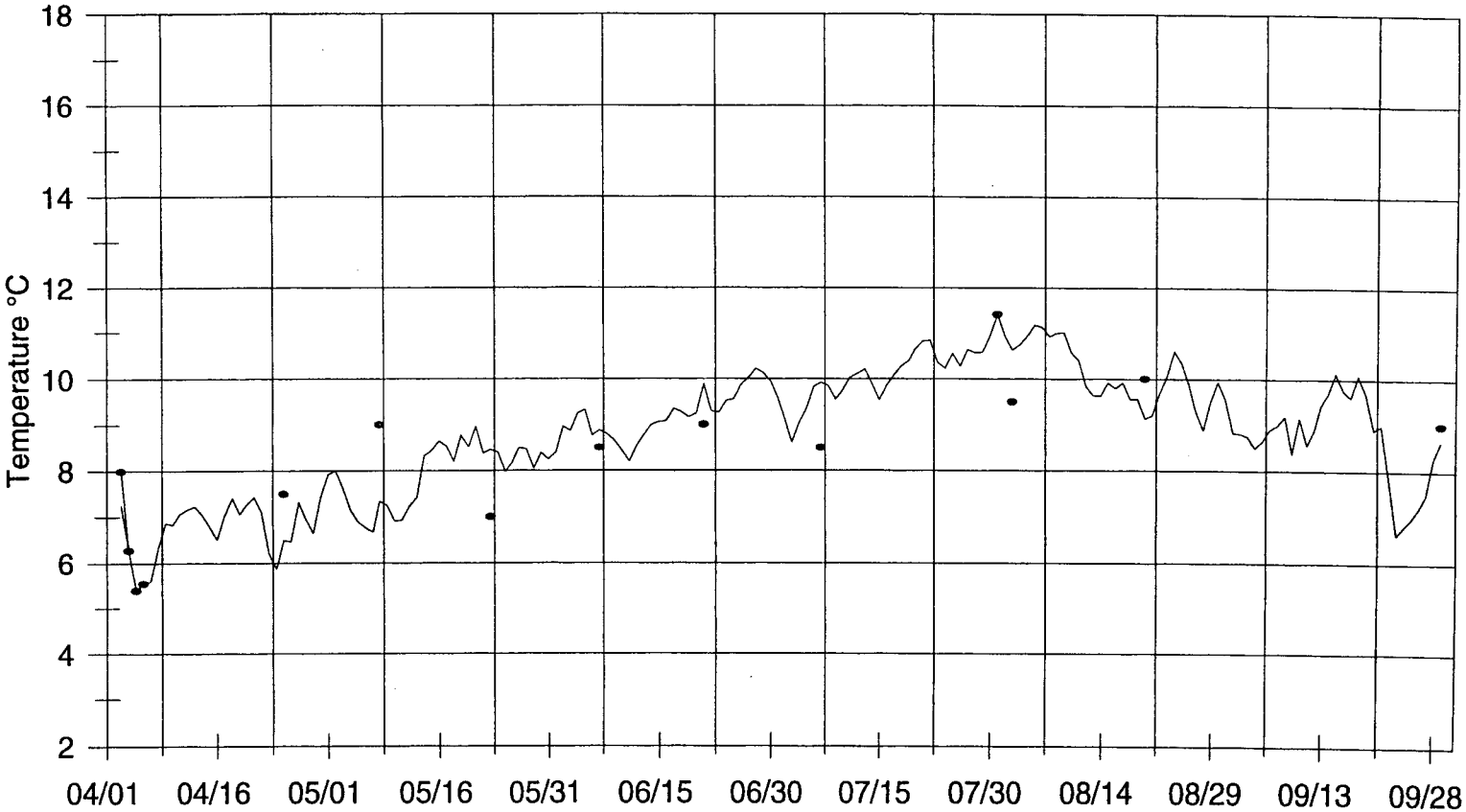
***APPENDIX B: THERMOGRAPHS OF AVERAGE DAILY  
TEMPERATURE AND INSTANTANEOUS TEMPERATURE  
MEASUREMENTS***

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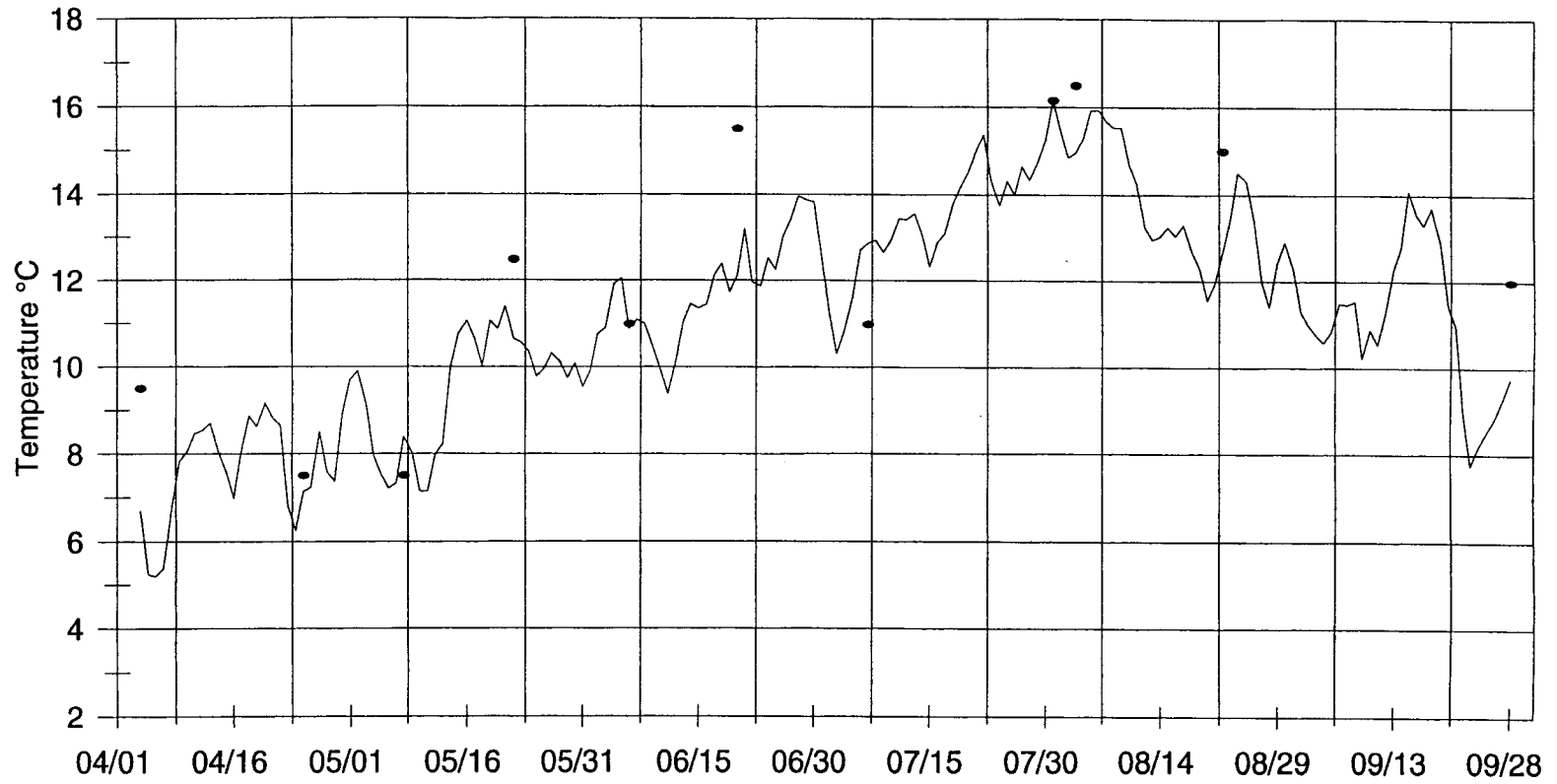
# First Creek

## Average Daily Temperature



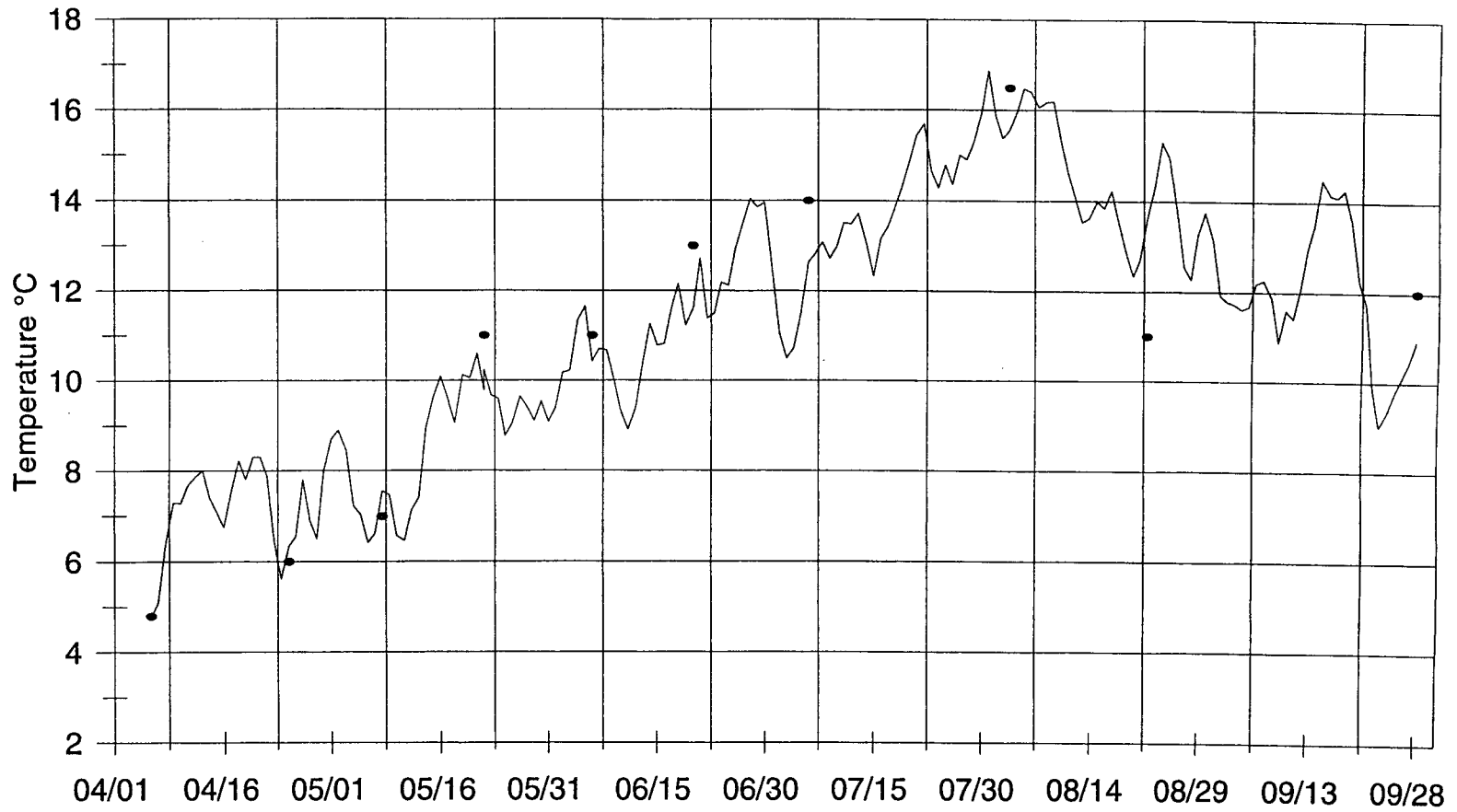
# Mitchell Creek

## Average Daily Temperature



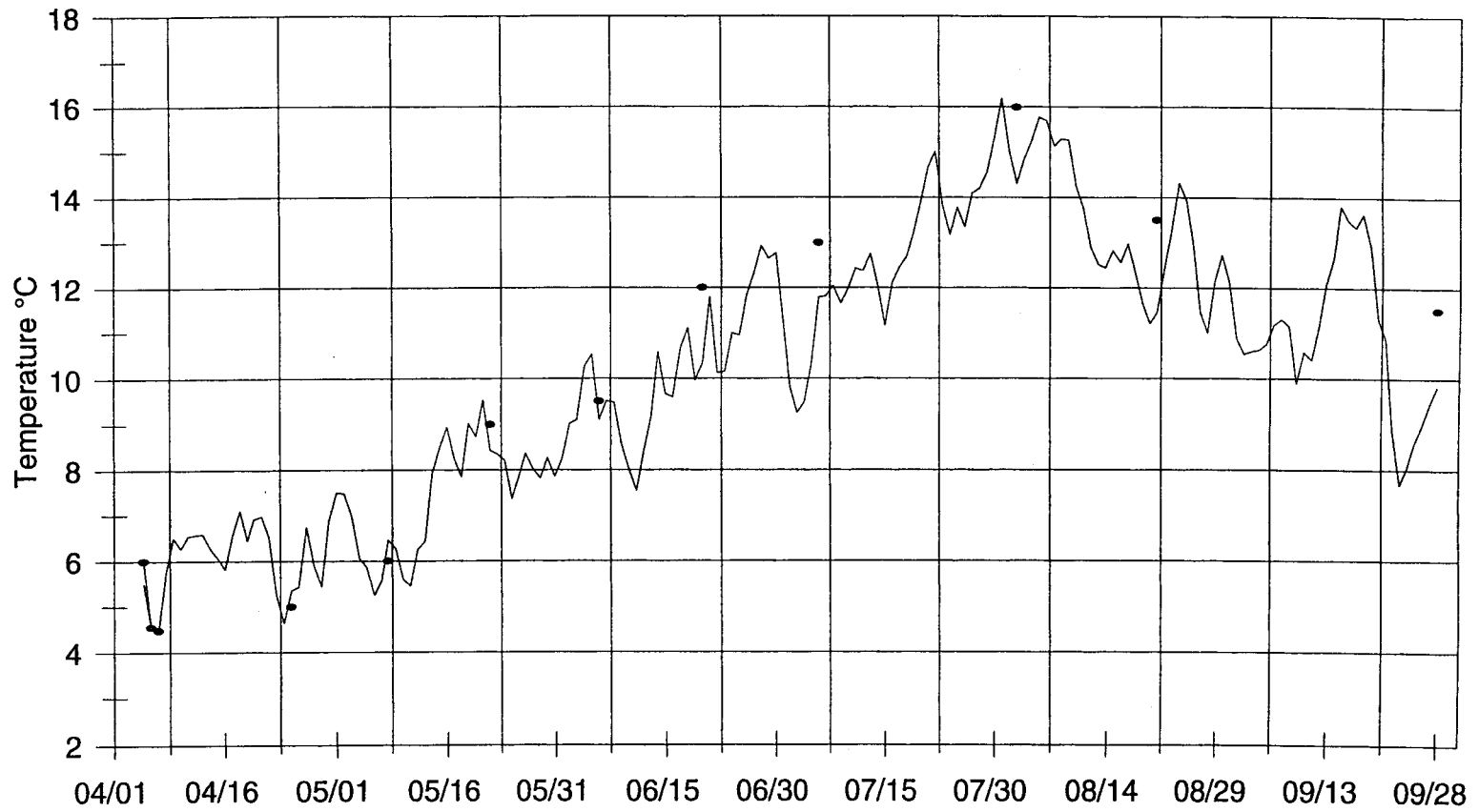
# Gold Creek

## Average Daily Temperature



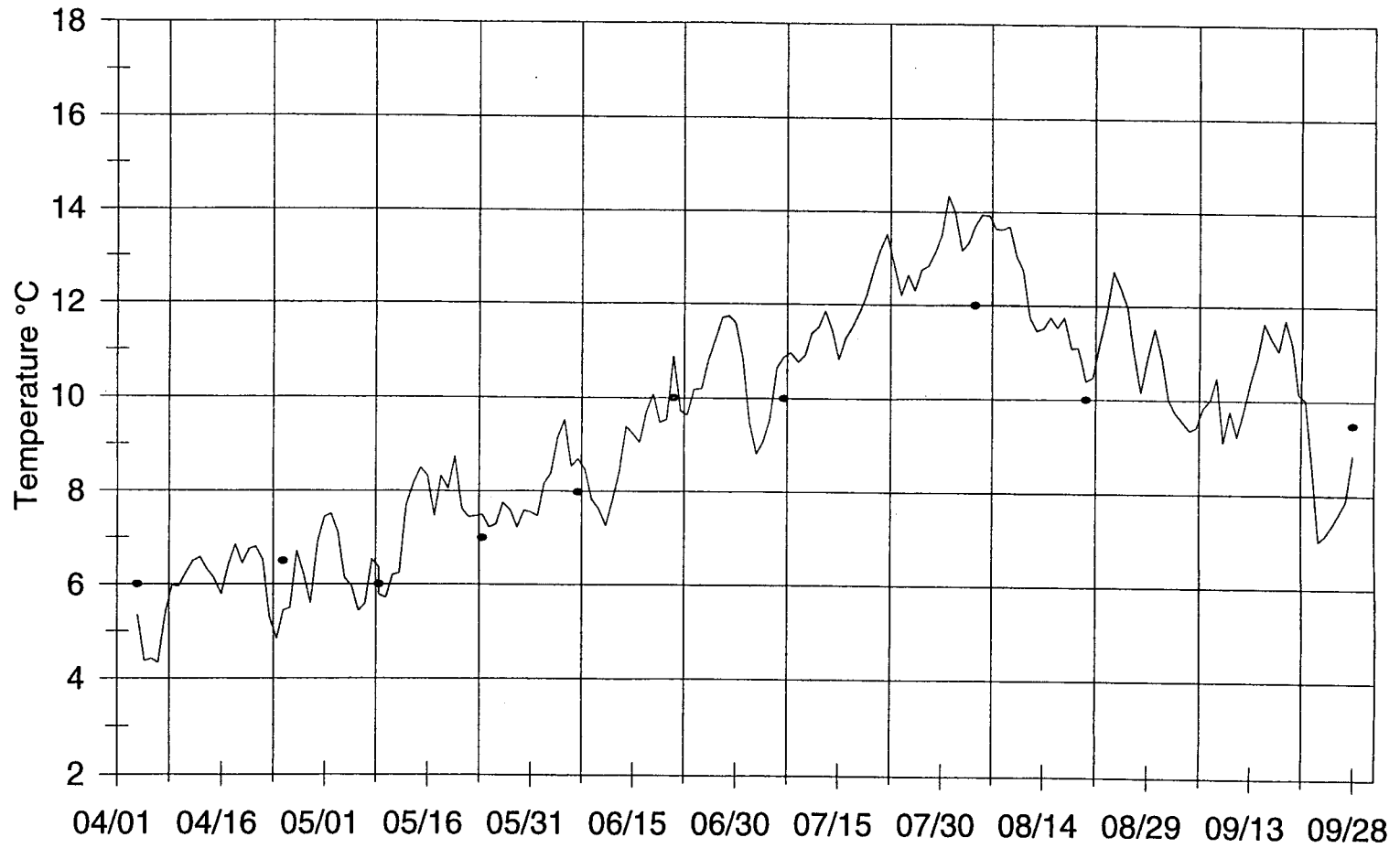
# Grade Creek

## Average Daily Temperature



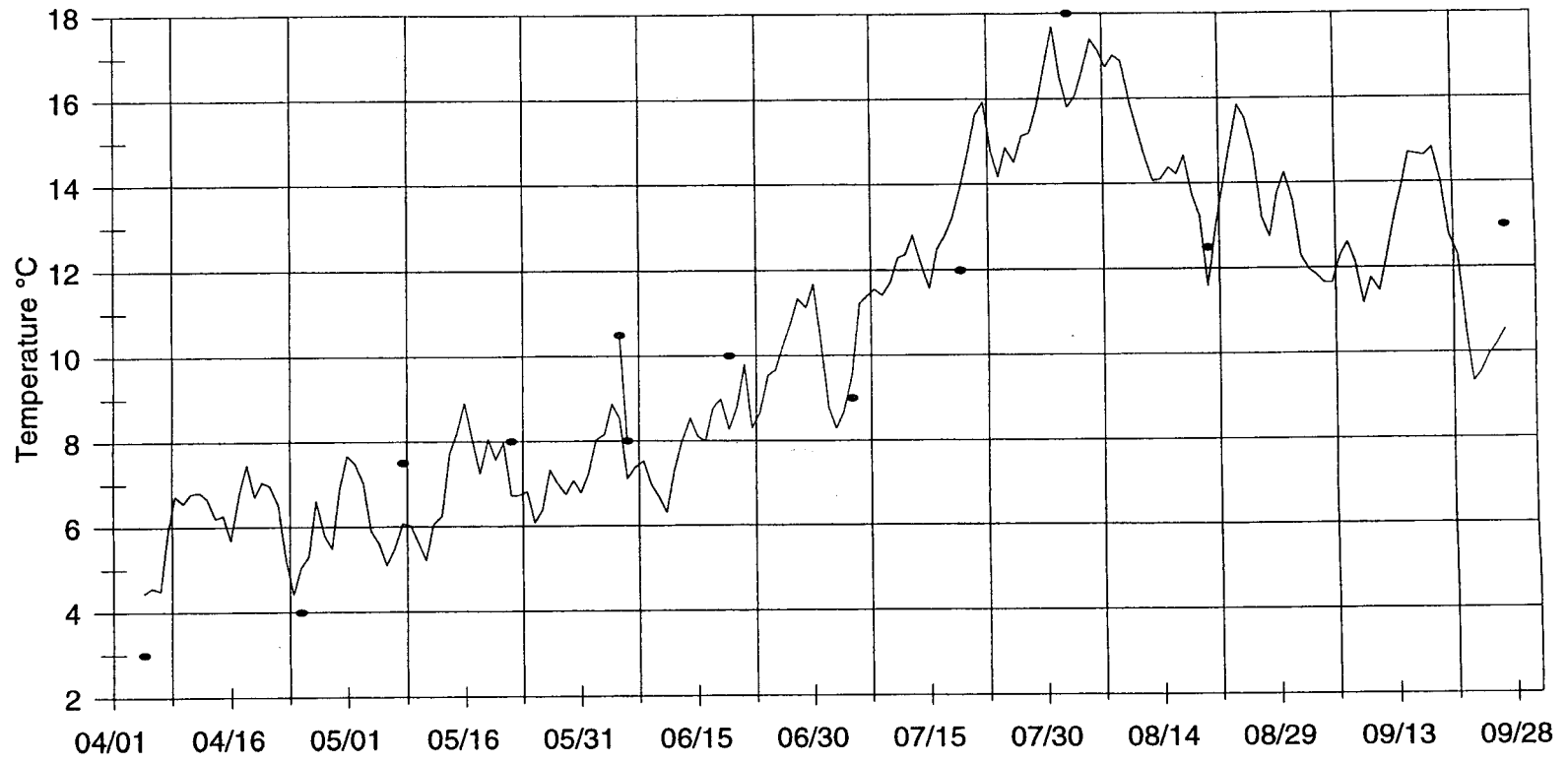
# 25 Mile Creek

## Average Daily Temperature



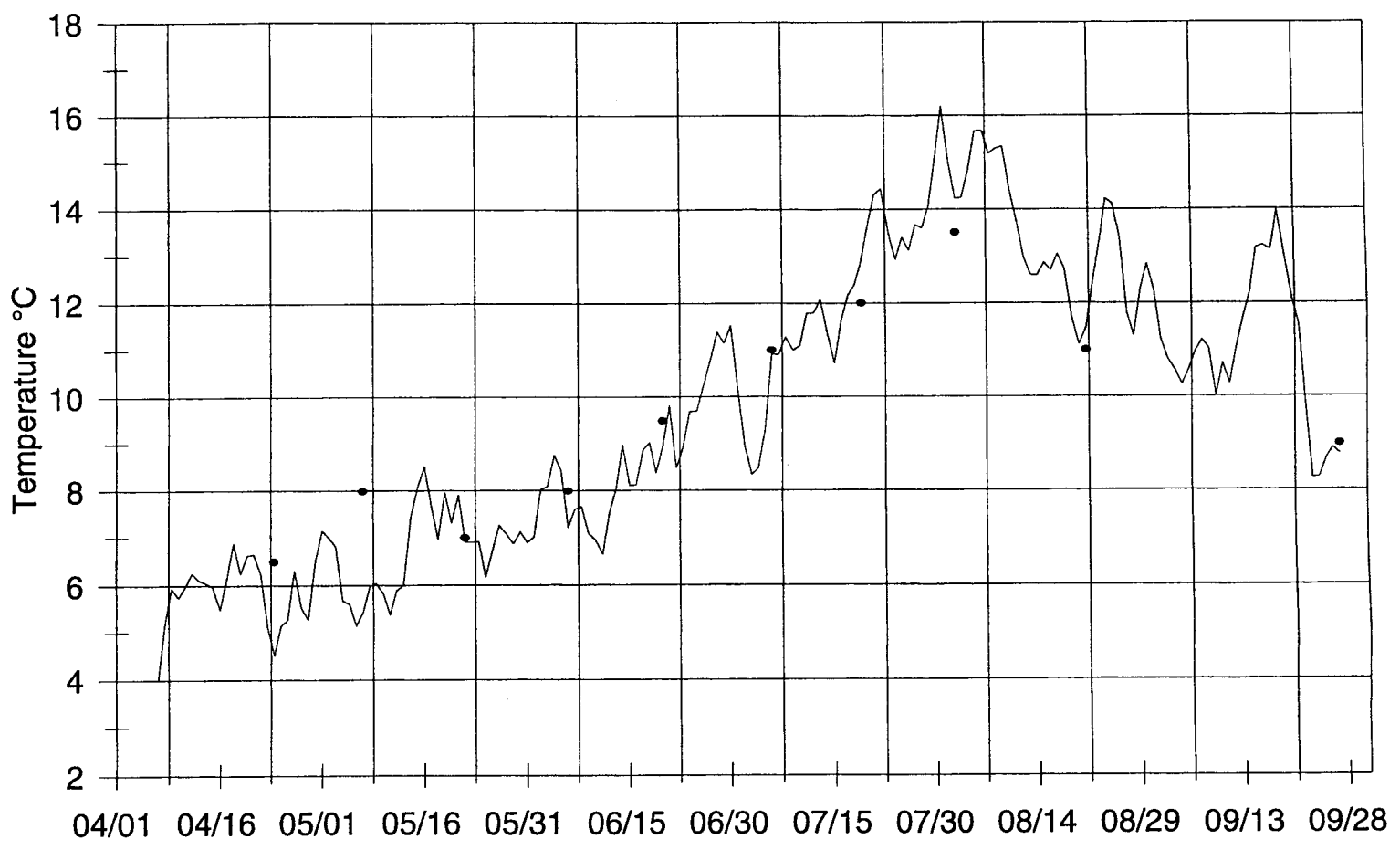
# Safety Harbor Creek

## Average Daily Temperature



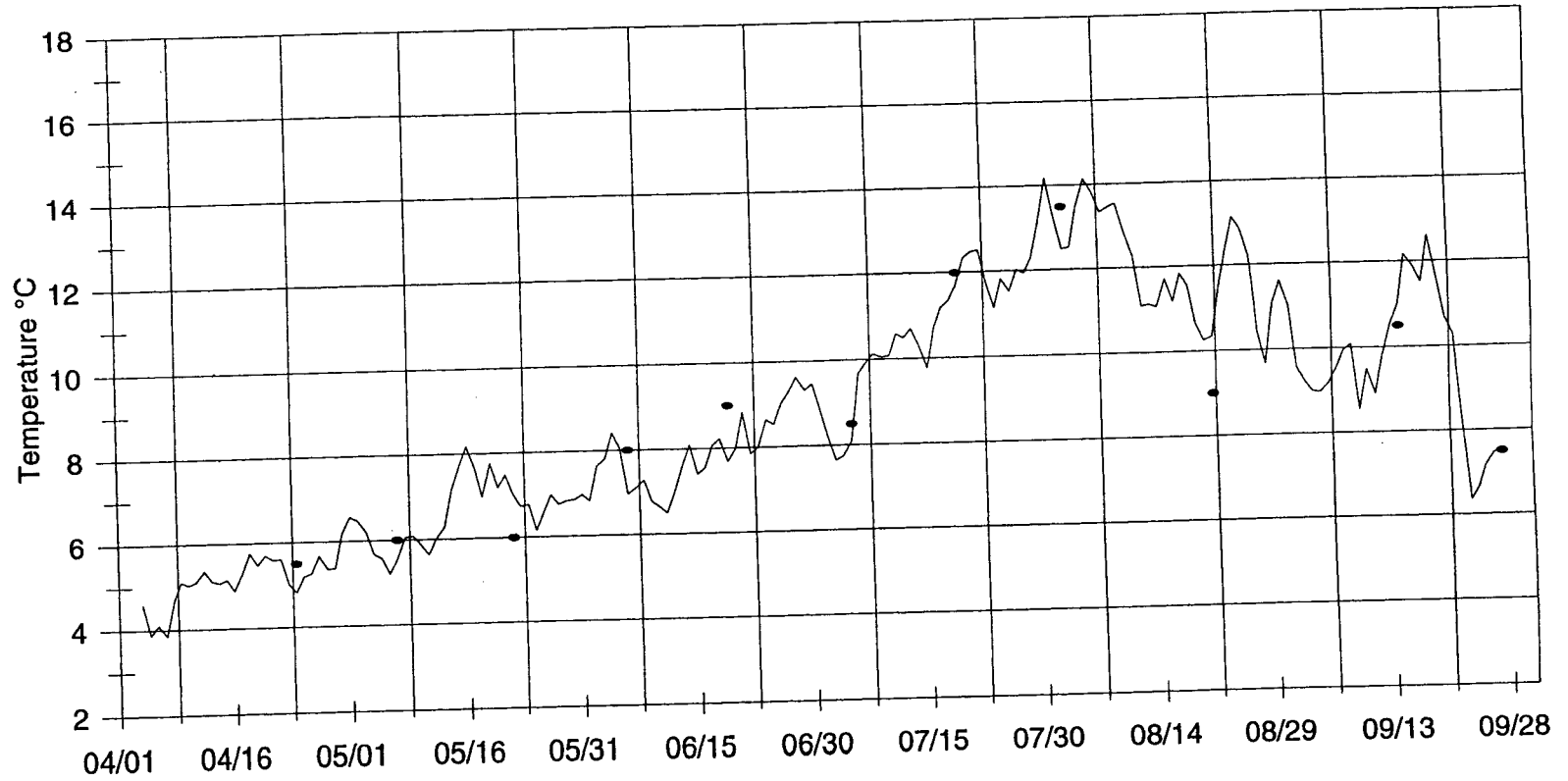
# Prince Creek

## Average Daily Temperature



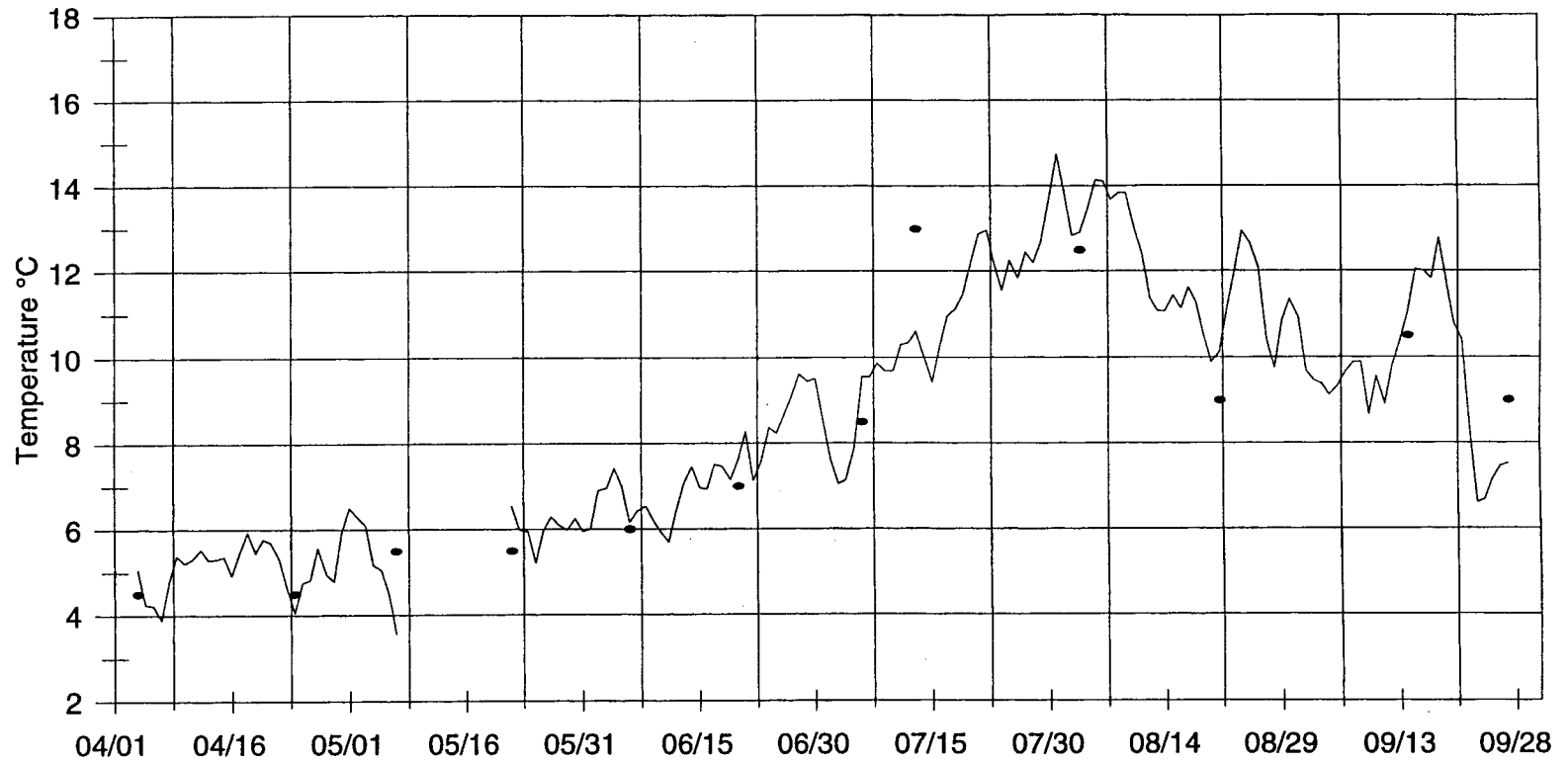
# Railroad Creek

## Average Daily Temperature



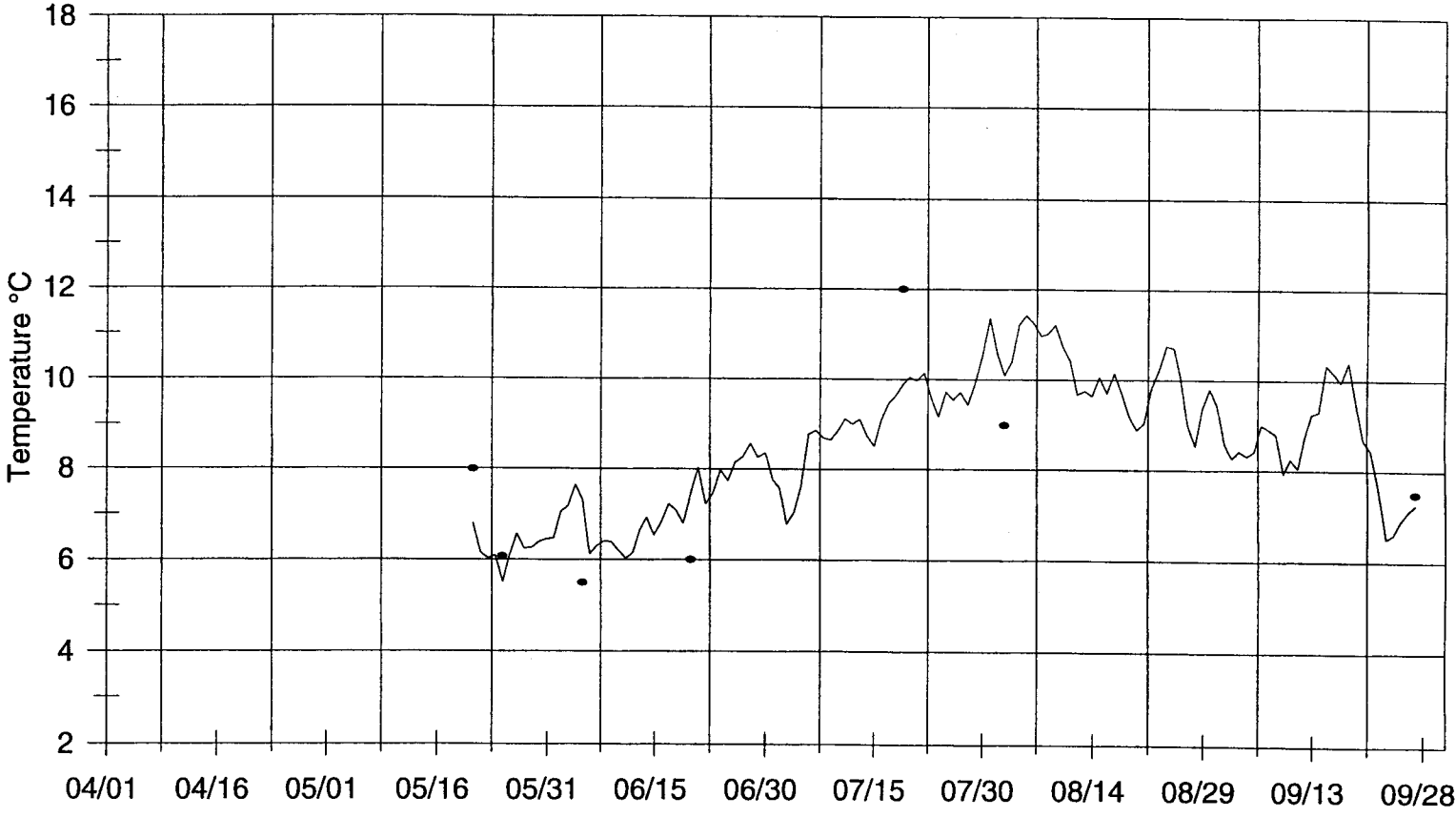
# Fish Creek

## Average Daily Temperature



# Blackberry Creek

## Average Daily Temperature



# Company Creek

## Average Daily Temperature

