Madison River Drainage Fisheries

and

Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program

2007
Annual Report
to
PPL Montana
Environmental Division
Butte
www.pplmontana.com

and

Turner Enterprises, Inc.
Bozeman

by

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Montana Fish, Wildlife, & Parks
Ennis
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Montana Fish, Wildlife & Parks
www.fwp.mt.gov

INTERNET WEB PAGES CITED IN THIS REPORT
(in alphabetical order)

Aquatic Nuisance Species Task Force……………..www.anstaskforce.gov
Blue Ribbon Flies …………………………………www.blueribbonflies.com
Ennis on the Madison Flyfishing Festival/Madison River Foundation…
www.ennisflyfishing.com
Lower Madison River Monitoring page….
www.madisondss.com/ppl-river.cfg/ppl-madison.php
Montana Fish, Wildlife, & Parks…………………..www.fwp.mt.gov
New Zealand Mudsnail in the Western USA……..
www.esg.montana.edu/aim/mollusca/nzms
PPL Montana……………………………………...www.pplmontana.com
Protect Your Waters………………………………www.protectyourwaters.net
Whirling Disease Foundation……………………..www.whirling-disease.org

MFWP personnel took all photos in this report unless otherwise credited.

FERC Articles addressed in this report

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EXECUTIVE SUMMARY

Beach seining for young-of-the-year Arctic grayling and mountain whitefish was conducted in early November. Only juvenile Utah chub and white sucker were captured. The US Fish & Wildlife Service determined Arctic grayling are not warranted for listing under the Endangered Species Act. Rainbow trout numbers remain high relative to populations since 1995 in all monitoring sections throughout the river, exceeding 3000/mile in Kirby, 1400/mile in Snoball, 1500/mile in Varney, and 2000/mile in Norris. Brown trout numbers are approaching 3000/mile in both Pine Butte and Varney, but are near the midpoint of their10 year range in Snoball at nearly 1400/mile and Norris at nearly 1300/mile. Water temperature was monitored at 14 sites and air temperature at 7 sites within the Madison Drainage. New Zealand mudsnails were found to be persistent throughout the river, but at the lowest densities since initial detection. Sentinel fish from captive rainbow trout stock are still severely infected by whirling disease in the river, but wild rainbows appear to be developing a resistance to the disease. The Sun Ranch hatchery was used to incubate eggs for the southwest Montana westslope cutthroat trout conservation and restoration program. The Cherry Creek Native Fish Introduction Project continued in 2007 with the first treatment of Phase 3, and a retreatment of the Cherry Creek mainstem in Phase 2. Four brook trout were found in Phase 2 after the treatment. Westslope cutthroat trout eyed egg introductions will begin in Phase 2 in 2008. Eyed egg introductions continued in Phase 1 of the project area where over 14,000 eggs were placed in streamside incubators, resulting in over 10,000 fry entering the stream. The West Madison Canal was monitored via electrofishing to assess characteristics of fish entrainment. Concerned anglers and citizens conducted fish salvage in the West Madison Canal after the headgate was closed in the Fall.

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INTRODUCTION

Montana Fish, Wildlife, & Parks (MFWP) has conducted fisheries studies in the Madison River Drainage since 1990 to address effects of hydropower operations at Hebgen and Ennis dams on fisheries, and to assess the status of the Arctic grayling *Thymallus arcticus* population of Ennis Reservoir (Byorth and Shepard 1990, MFWP 1995, MFWP 1996, MFWP 1997, MFWP 1998a, MFWP 1999a, MFWP 2000, MFWP 2001, MFWP 2002, MFWP 2003, MFWP 2004a, MFWP 2005, MFWP 2006, MFWP 2007). This work has been funded through an agreement with the owner and operator of the dams, initially Montana Power Company (MPC), now PPL Montana. The original agreement between MFWP and MPC was designed to anticipate relicensing requirements for MPC's hydropower system on the Madison and Missouri rivers, which includes Hebgen and Ennis dams, as well as seven dams on the Missouri River (Figure 1). PPL Montana has maintained the direction set by MPC, and convened several committees to address fisheries, wildlife, water quality, and recreation issues related to the operation of the hydropower facilities on the Madison and Missouri rivers. These committees are composed of representatives of PPL Montana and several agencies. Each committee has an annual budget and authority to spend money that is provided to them by PPL Montana to address the requirements of PPL Montana's FERC license for operating the Madison & Missouri dams. The Madison Fisheries Technical Advisory Committee (MadTAC) is composed of personnel of PPL Montana, MFWP, the U.S. Fish & Wildlife Service (USFWS), the U.S. Forest Service (USFS), and the U.S. Bureau of Reclamation (BLM). Each entity has equal authority in decision making within the TAC. Collectively, the nine dams on the Madison and Missouri rivers are called the 2188 Project, which refers to the Federal Energy Regulatory Commission (FERC) license number that authorizes their operation. The Federal Energy Regulatory Commission issued PPL Montana a license to operate the 2188 Project for 40 years (Federal Energy Regulatory Commission 2000). The license details the terms and conditions PPL Montana must meet during the license term, including fish, wildlife, and recreation protection, mitigation, and enhancement measures.

During the late 1990's, numerous entities developed the Memorandum of Understanding and Conservation Agreement for Westslope Cutthroat Trout in Montana (MUCAWCTM). The MUCAWCTM, which was formalized in 1999 (MFWP 1999b), identifies Conservation & Restoration Goals and Objectives for westslope cutthroat trout (WCT) *Oncorhynchus clarki lewisi* in Montana. The Plan states "The management goal for westslope cutthroat trout in Montana is to ensure the long-term, self-sustaining persistence of the subspecies within each of the five major river drainages they historically inhabited in Montana (Clark Fork, Kootenai, Flathead, upper Missouri, and Saskatchewan), and to maintain the genetic diversity and life history strategies represented by the remaining populations." Objectives are:

1. Protect all genetically pure WCT populations
2. Protect introgressed (less than 10% introgressed) populations
3. Ensure the long-term persistence of WCT within their native range
4. Providing technical information, administrative assistance, and financial resources to assure compliance with listed objectives and encourage conservation of WCT

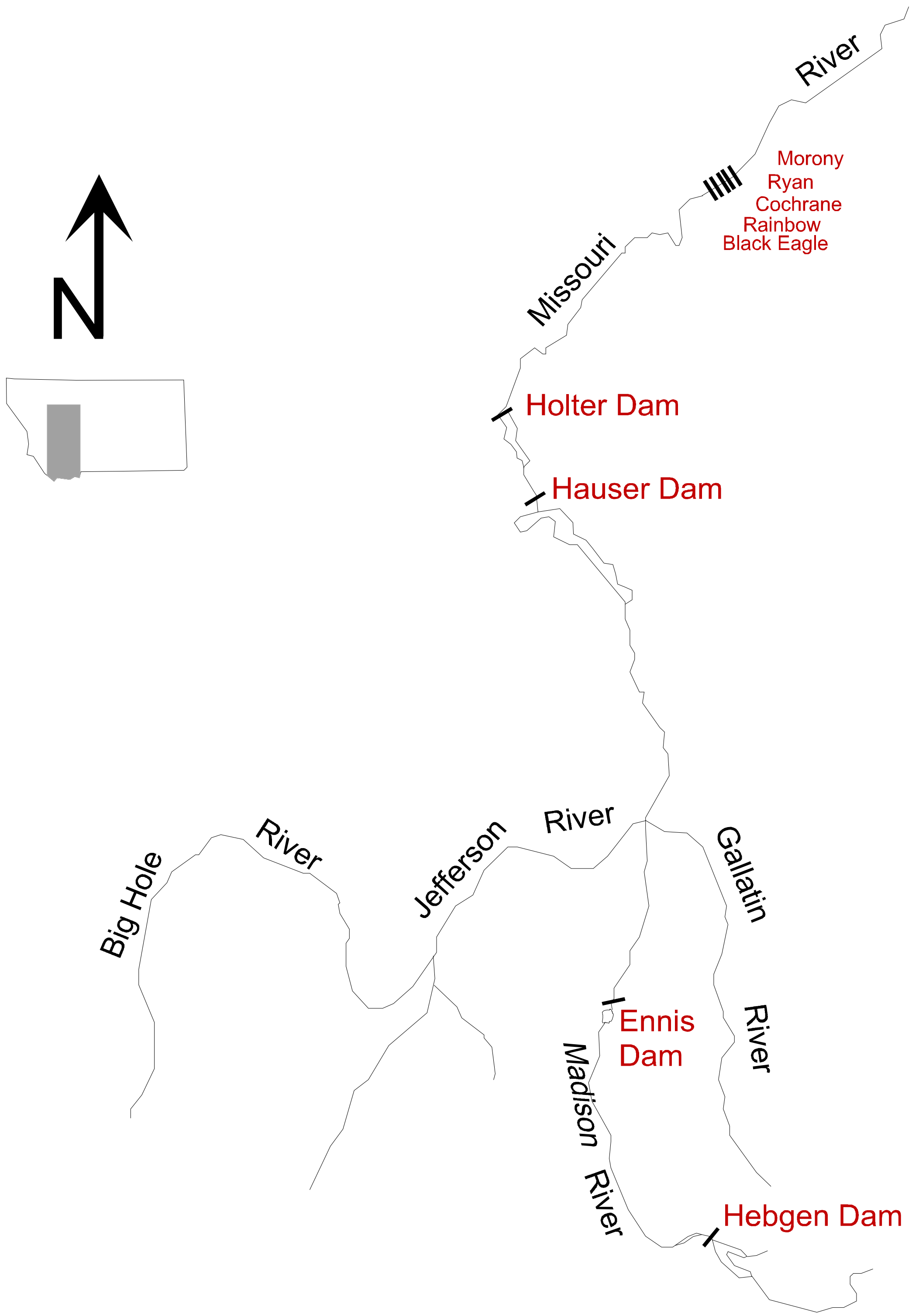


Figure 1. Locations of PPL Montana dams on the Madison and Missouri rivers (FERC Project 2188).

5. Design and implement an effective monitoring program by the year 2002 to document persistence and demonstrate progress towards goal

Objective 3 further states "The long-term persistence of westslope cutthroat trout within their native range will be ensured by maintaining at least ten population aggregates throughout the five major river drainages in which they occur, each occupying at least 50 miles of connected habitat…". Within the Missouri River Drainage, four geographic areas are identified, including the upper Missouri, which consists of the Big Hole, Gallatin, and Madison subdrainages.

Entities participating in the development of the MUCAWCTM were American Wildlands, Montana Chapter of the American Fisheries Society, Montana Department of Natural Resources and Conservation (MDNRC), Montana Farm Bureau, MFWP, Montana Stockgrowers Association, Montana Trout Unlimited, Montana Wildlife Federation, Natural Resource Conservation Service, BLM, USFS, USFWS, and private landowners.

In 2006, the MUCAWCTM was updated and combined with a similar document for Yellowstone Cutthroat Trout *Oncorhynchus clarki bouvieri*.

Late in 1996, MFWP initiated a program entitled "The Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program". The goal of this effort is to conserve and restore the native westslope cutthroat trout in the Madison River drainage. Fieldwork for this effort began in 1997 in tributaries of the Madison River. The agreement between MFWP and PPL Montana includes provisions to address issues regarding species of special concern.

In recognition of the severity of the situation faced by the westslope cutthroat trout, and in keeping with the philosophy of promoting native species on their properties, Turner Enterprises, Incorporated (TEI) offered access to the Cherry Creek drainage on the Flying D Ranch to assess its suitability for introducing westslope cutthroat. Cherry Creek, a tributary to the Madison River, was identified as an opportune location to introduce genetically pure WCT, and it will provide an opportunity to meet or fulfill MUCAWCTM objectives 3, 4, & 5. MFWP determined in 1997 that introducing westslope cutthroat to Cherry Creek is feasible, but would require the removal of all non-native trout presently in that portion of the drainage (Bramblett 1998, MFWP 1998b). MFWP, TEI, and the Gallatin National Forest (GNF) subsequently entered into an agreement to pursue this effort. The agreement outlines the roles and responsibilities of each party, including the GNF, which manages the public land at the upper end of the Cherry Creek drainage. Administrative and legal challenges to the Cherry Creek Project delayed its implementation from 1999 - 2002. The project was successfully implemented in 2003.

In 2001, the Sun Ranch entered into an agreement to assist MFWP with westslope cutthroat trout conservation and recovery. The ranch built a small hatchery facility and a rearing pond to facilitate development of a westslope cutthroat trout broodstock for the Madison and Missouri river drainages, and provided personnel to assist with fieldwork and conduct hatchery operations.

METHODS

Madison Grayling

A beach seine (Figure 2) is used to monitor index sites in Ennis Reservoir for young-of-the-year grayling and other fish species. Seining is conducted by pulling a 125 x 5 foot fine-mesh net along shallow areas in the reservoir.

Figure 2. Beach seining in Ennis Reservoir.

Gillnetting

Gillnetting was conducted in Ennis Reservoir in late August. Experimental nets, composed of five 25-foot panels of progressively larger mesh (¾”, 1”, 1 ¼”, 1 ¾” 2”) were set at four locations and left to fish overnight (Figure 3). Floating nets were used at the shallow south end of the reservoir, and one floating and one sinking net were used at the deeper north end. Because the south end of the reservoir is so shallow, floating nets are capable of sampling nearly the entire water column. At the deeper north end, a floating net and a sinking net were required to sample pelagic and benthic areas, respectively. Captured fish were removed from the nets, separated by species, measured, weighed, enumerated, and released.

Population Estimates

Electrofishing from a driftboat mounted mobile anode system (Figure 4) is the principle method used to capture Madison River trout for population estimates in several sections of the Madison River (Figure 5). Fish captured for population estimates are weighed and measured, marked with a fin clip, and released. A log-likelihood statistical analysis (MFWP 2004b) is used to estimate trout populations.

Over the past two years, estimates for all sections and all years have been converted from age-based estimates to length-based estimates due partially to the major time requirement necessary to age fish, and to maximize the statistical probability that the estimates are accurate.

River Discharge

Article 413 of the FERC license mandates PPL Montana to monitor and mitigate thermal effects in the lower river (downstream of Ennis Reservoir). In coordination with agencies, the company has developed and implemented remote temperature monitoring system and a 'pulsed' flow system to accomplish this. Real-time or near real-time meteorological and temperature monitoring is conducted to predict water temperature the following day, which determines the volume of discharge that will occur. Pulsed flows are triggered when water temperature at the Madison (Ennis) Powerhouse is 68^{o} F or higher and forecast air temperature at Three Forks for the following day is 80^{o} F or higher. The volume of water released in the pulse is determined by how much the water and/or air temperature exceeds the minimum thresholds (Table 1). The increase in water volume in the lower river reduces the peak water temperature that would occur at the 1100 cfs base flow. Discharge from Ennis Dam is increased in the early morning so that the greatest volume of water is in the area of Black's Ford and downstream during the late afternoon when daily solar radiation is highest. The increased volume of water reduces the peak water temperature in the lower river reducing or eliminating the potential for thermally induced fish kills. Discharge from Hebgen Dam typically does not fluctuate on a daily basis during pulse flows, but is occasionally adjusted to increase or decrease the volume of water going into Ennis Reservoir, where daily fluctuations in the lower river are controlled.

The meteorological and temperature data monitored in the lower river may be viewed in real-time or near-real time at http://www.madisondss.com/ppl-river.cfg/ppl-madison.php.

Article 419 of the FERC license requires the company to develop and implement a plan to coordinate and monitor flushing flows in the Madison River downstream of Hebgen Dam. A flushing flow is a flood stage of runoff that mobilizes streambed materials, resulting in scour in some locations and deposition in other locations. This is a natural occurrence in unregulated streams and rivers, and renews spawning, rearing, and food producing areas for fish, as well as providing fresh mineral soil for terrestrial vegetation and other wildlife needs.

Temperature Monitoring

Water temperature was recorded at 14 sites and air temperature at seven sites throughout the course of the Madison River from above Hebgen Reservoir to the mouth of the Madison River at Headwaters State Park (Figure 6). Optic StowAway temperature loggers recorded temperature in Fahrenheit every 30 minutes. Air temperature recorders were placed in areas that were shaded 24 hours per day.

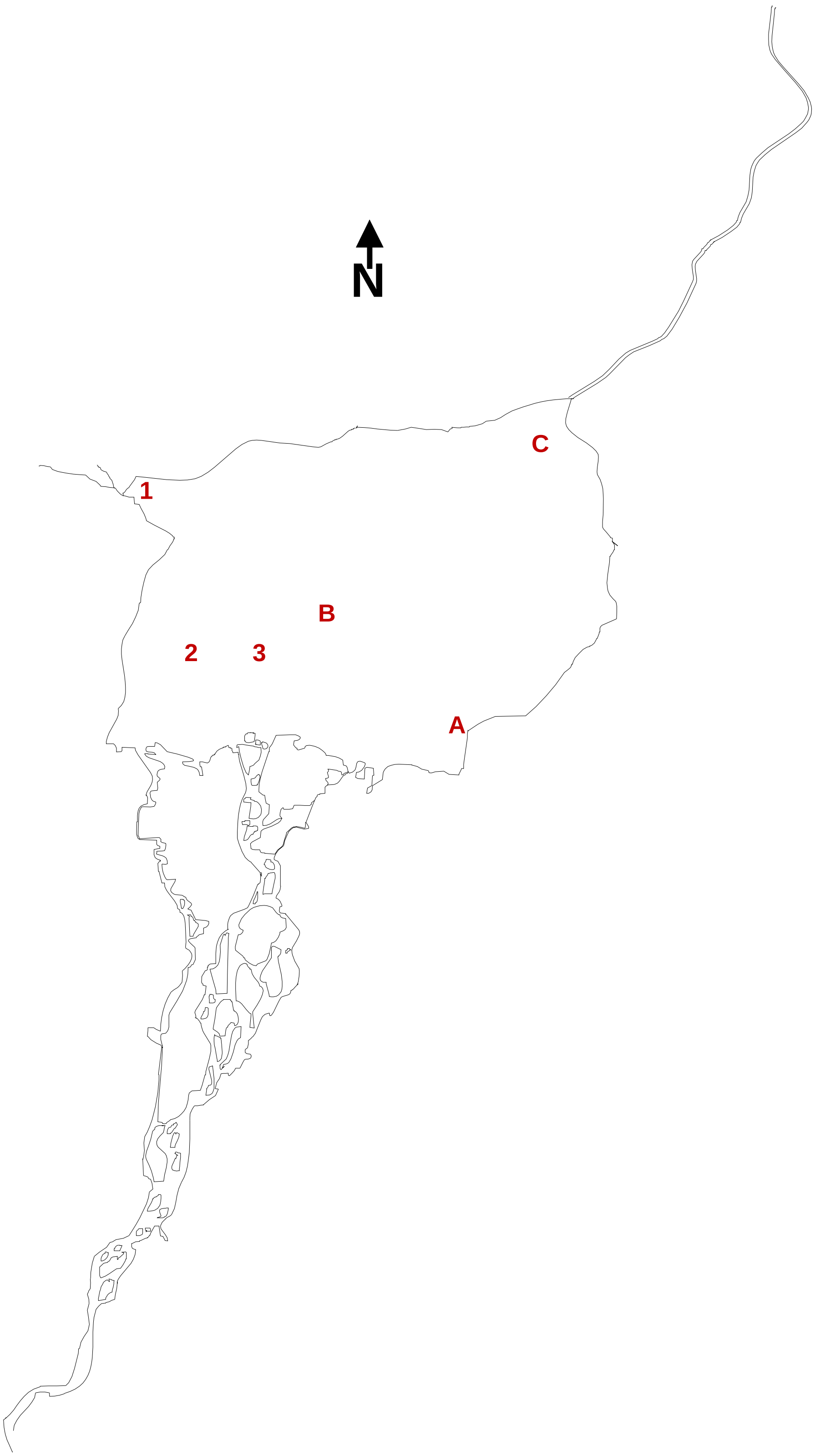


Figure 3. Locations of Ennis Reservoir seining (numbers) and gillnetting (letters) sites.

Figure 4. Electrofishing (shocking) in the Norris section of the Madison River.

Aquatic Nuisance Species

Highway signs announce FWP's West Yellowstone Traveler Information System (TIS) (Figure 7). The five signs are located near major highway intersections in the West Yellowstone area, notifying drivers entering and leaving the area of the TIS system. The TIS notifies anglers and water recreationists of the presence of New Zealand mudsnails in the Madison River and Hebgen Reservoir, and instructs them on methods of reducing the likelihood of transporting New Zealand mudsnails and other ANS to other waters. Additional messages broadcast by the system include messages on whirling disease, zebra mussels, weed control, and TIPMont, the FWP hotline to report hunting & fishing violations. The system broadcasts at the AM frequency of 1600 KHz. Funding for the purchase, installation and signage of the system was provided by a $9,800 grant from the Pacific States Marine Fisheries Commission as part of an effort to prevent the westward spread of zebra mussels.

The State of Montana hired an Aquatic Nuisance Species Coordinator in 2004. The position is responsible for developing and coordinating ANS control & management activities among state agencies as well as between state and non-state entities. The ANS Coordinator is responsible for developing and coordinating Hazard Analysis and Critical Control Point (HACCP) Training to State employees and other groups. The HACCP Program is a method to proactively plan and implement measures to prevent the inadvertent spread of ANS during work activities. The ANS Coordinator is an employee of FWP.

New Zealand Mudsnails

New Zealand Mudsnails have spread throughout the Madison River since first detected in 1994. PPL Montana and FWP each maintain monitoring sites at various

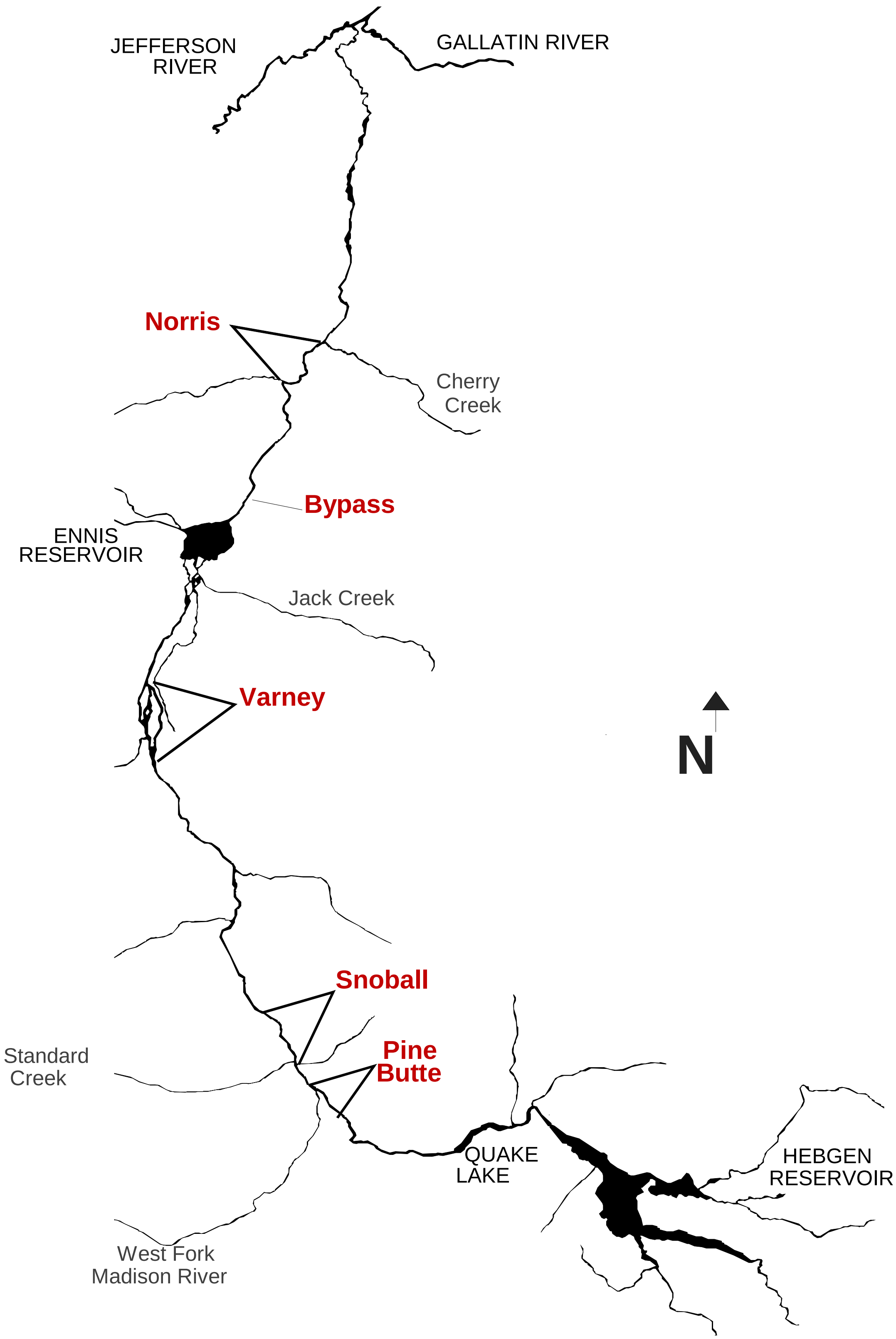


Figure 5. Locations of Montana Fish, Wildlife, & Parks 2007 Madison River population estimate sections.

Table 1. Pulse flow trigger criteria

	Water temperature at Madison (Ennis) Powerhouse	Tomorrow's Maximum Forecast Air Temperature at Three Forks		
		Pulse Flow Rate (McAllister Discharge)		
No Pulsing Required	Less than 68°F	No action		
Pulsing Contingent on Weather Forecast	$\geq$ 68°, < 70°	< 80°	$\geq$ 80°	
		No action	1400 cfs	
Pulsing Required, Volume Contingent of Weather Forecast > 90°F	$\geq$ 70°, < 72°	< 90°	$\geq$ 90°, < 95°	$\geq$ 95°
		1400 cfs	1600 cfs	2100 cfs
Pulsing Required, Volume Contingent of Weather Forecast > 85°F	$\geq$ 72°, < 73°	< 85°	$\geq$ 85°, < 90°	$\geq$ 90°
		1400 cfs	1600 cfs	2100 cfs
Pulsing Required, Volume Contingent of Weather Forecast > 85°F	$\geq$ 73°	< 85°	$\geq$ 85°	
		1800 cfs	2400 cfs	

locations within the Madison Drainage.

Whirling Disease

Whirling disease monitoring has been conducted in the Madison River since 1996 by using sentinel cage techniques. Each cage holds 50 young-of-the-year rainbow trout for 10 days. At the end of the 10 day period, fish are transferred to whirling disease free water in a laboratory where they are held until they are 90 days old, at which time they are euthanized and sent to the Washington Animal Disease Diagnostic Lab (WADDL) for analyses. Juvenile rainbow trout used in the studies are not offspring of Madison River fish, but are from the same captive stock used since studies began in 1996. This stock has been used continuously over the years to allow comparison over time and between various rivers.

Dave Kumlien, Executive Director of the Whirling Disease Foundation, presents two articles regarding whirling disease on the Blue Ribbon Flies webpage. These articles summarize some of the advances that have been made by whirling disease researchers and additional information that is needed. To view these and other articles, go to www.blueribbonflies.com, click on Journal, then on Articles and Essays.

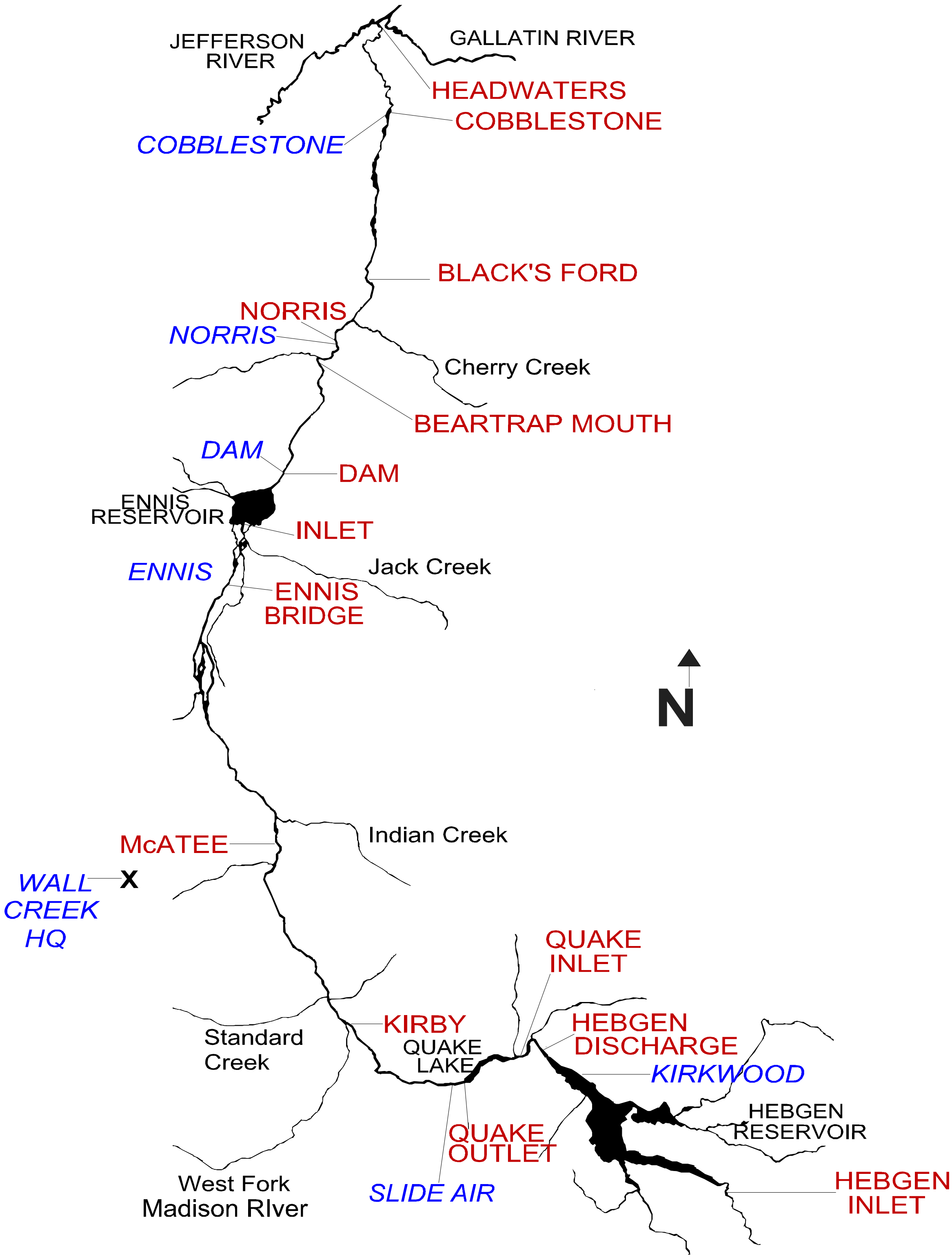


Figure 6. Locations of Montana Fish, Wildlife, & Parks annual temperature monitoring sites. Air temperature sites are blue, water temperature sites are in red.

Figure 7. Roadside sign announcing the Traveler Information System at West Yellowstone.

Westslope Cutthroat Trout Conservation and Restoration

Efforts to conserve and restore genetically pure westslope cutthroat trout in the Madison Drainage center on maintaining genetically pure populations, high quality stream habitat, adequate instream flow, and, where necessary, removal of competing or hybridizing non-native trout. Stream habitat surveys were conducted throughout much of the Madison Drainage from 1997 – 1999 (MFWP 1998a, Sloat et al. 2000). Backpack electrofishing was used to survey fish species. Removal of non-native species will require use of the EPA registered piscicides (fish-pesticides) rotenone or antimycin.

The Madison District of the U.S. Forest Service conducts projects to benefit westslope cutthroat trout and to restore stream habitat in tributaries to the Madison River. Grant money from the PPL Montana relicensing agreement paid for materials and operations, and members of the Madison River Foundation, the Madison-Gallatin Chapter of Trout Unlimited, and the Montana Conservation Corps provided labor.

Sun Ranch Westslope Cutthroat Trout Brood

Gametes (eggs & sperm) for the Sun Ranch Westslope Cutthroat Trout program were collected from three streams and from the Sun Ranch Pond in 2007. All fertilized eggs were transported to the Sun Ranch Hatchery for incubation and hatching (Figure 8), and a portion of the resulting fry were introduced to the Sun Ranch Brood Pond (Figure 9) to contribute to the Sun Ranch brood development. Fry from the Sun Ranch Pond broodstock were used for introductions in Cherry Creek and stocked into the pond to facilitate development of the Sun Ranch brood.

Occasionally, when project personnel are unavailable to do so, USFWS personnel from the Ennis National Fish Hatchery caretake the eggs or fry at the Sun Ranch Hatchery. Generally, this requires few days each year, but is an important contribution to the program.

Cherry Creek Native Fish Introduction Project

The Cherry Creek Native Fish Introduction Project was initiated in 2003. The project area is comprised of over 60 miles of stream habitat and the 7-acre, 105 acre-foot Cherry Lake, and includes all of the Cherry Creek Drainage upstream of a 25-foot

Figure 8. Sun Ranch Hatchery rearing troughs.

Figure 9. Sun Ranch Brood Pond.

waterfall approximately 8 miles upstream of the Madison River confluence (Figure 10). The only fish species present in the project area in 2003 were brook trout, rainbow trout, and Yellowstone cutthroat trout (YCT) (Figure 11). The large size of the project area requires that the project be completed in phases. Each phase will be treated for at least two consecutive years. Phase 1 was treated in 2003 & 2004, Phase 2 in 2005 & 2006, and in 2007 a third treatment of the Phase 2 mainstem and the first treatment of all of Phase 3 mainstem and tributaries was conducted.

Figure 10. Cherry Creek waterfall at stream mile 8.0. This falls is the downstream extent of the project area.

Preparatory fieldwork consisted of determining stream flow time, placing application station markers, posting sentinel fish, setting up the detoxification station, and some electrofishing to assess thoroughness of previous years treatments.

Fintrol was unavailable for use at Cherry Creek in 2007 due to a production problem, so a rotenone product called CFT Legumine was used. Bioassays were conducted in the East Fork Cherry Creek in late July to determine the effective exposure time of the CFT (Table 2). Based on bioassay results and CFT label instructions, CFT was applied to the stream during the treatment at no more than 1.0 part-per-million (ppm) for seven hours. Treatments were initiated on August 1.

Stream discharge was measured following standard USGS protocols, and a staff gauge was temporarily placed to determine if discharge changed appreciably during or prior to treating a given section of stream. Discharge was measured in a stream section the evening prior to treatment of that section, which allowed calculation and preparation of the piscicide that night or the next morning.

Stream treatments were made using trickle application systems (Figure 12). The system consists of a 3½ gallon plastic bucket & lid, garden hose, a gate valve, and a commercially available automatic dog watering bowl. A plastic elbow is fixed to a hole drilled in the bottom of the bucket, a short section of garden hose and the gate valve is clamped to the elbow (Figure 13), and a longer section of garden hose attached the assembly to the dog waterer. The bucket is partially filled with filtered stream water, the CFT is added, then the bucket is topped off with filtered stream water and stirred with a wooden dowel. At a predetermined time, the gate valve is opened, allowing the mixture to flow into the bowl, where it then trickles into the stream through a small hole drilled in the bottom of the bowl (Figure 14). Typically, one bucket empties in 3 to 3½ hours. Applications are designed using a 7-hour application period, so the bucket must be refilled and the process repeated once at each application point each day.

Stations were placed at selected points along the stream and started at predetermined times to coordinate application of the mixture with other stations along the stream. Backpack sprayers were used each day to treat off-channel water and larger pools.

Westslope cutthroat eggs from three wild donor streams, the Sun Ranch brood, and the Washoe Park Hatchery were reared to the eyed stage the plavced in remote streamside incubators (RSI) (Figure 15) in both forks of Phase 1. Eggs completed incubation in the RSI, hatched, and fry departed the RSI into the stream under their own power. The RSI is plumbed to allow stream water to flow into the bottom of the bucket, percolate up through an artificial substrate where the eggs are placed, and out the RSI near the top of the bucket. When ready to enter the stream, fry follow the water out the hole near the top of the bucket.

A capture bucket was placed on the outflow of the RSI to capture and enumerate departing fry to allow estimation of survival in the RSI.

Fish Entrainment

Efforts have been initiated to evaluate fish entrainment into irrigation ditches along the Madison River. Ditches are observed from public roads or where they traverse across public land, or with permission of the water right holders. Surveys are conducted in the fall to determine if significant numbers of fish enter into ditches and become stranded after the headgate is closed, thus lost to the river population. Surveys are conducted annually for at least several years, and will also be conducted as drought diminishes and normal and high water years occur.

In 2007, the West Madison Canal was monitored by electrofishing to determine characteristics of fish entrainment. Three 500-foot sections were established. The sections were called Eight-mile, Willow Ranch, and Range View Road (Figure 16), which are approximately one, four, and six miles respectively below the headgate on the Madison River (Figure 17). Monitoring was conducted eight times from May 16 – October 17. Captured fish were speciated, enumerated, measured for length & weight, examined for disease symptoms, and fin clipped. Fish larger than 6 inches were also tagged with a colored stringer tag. Each of the 3 sections was assigned a specific tag color to determine movement between sections and to determine distribution throughout the ditch during salvage efforts.

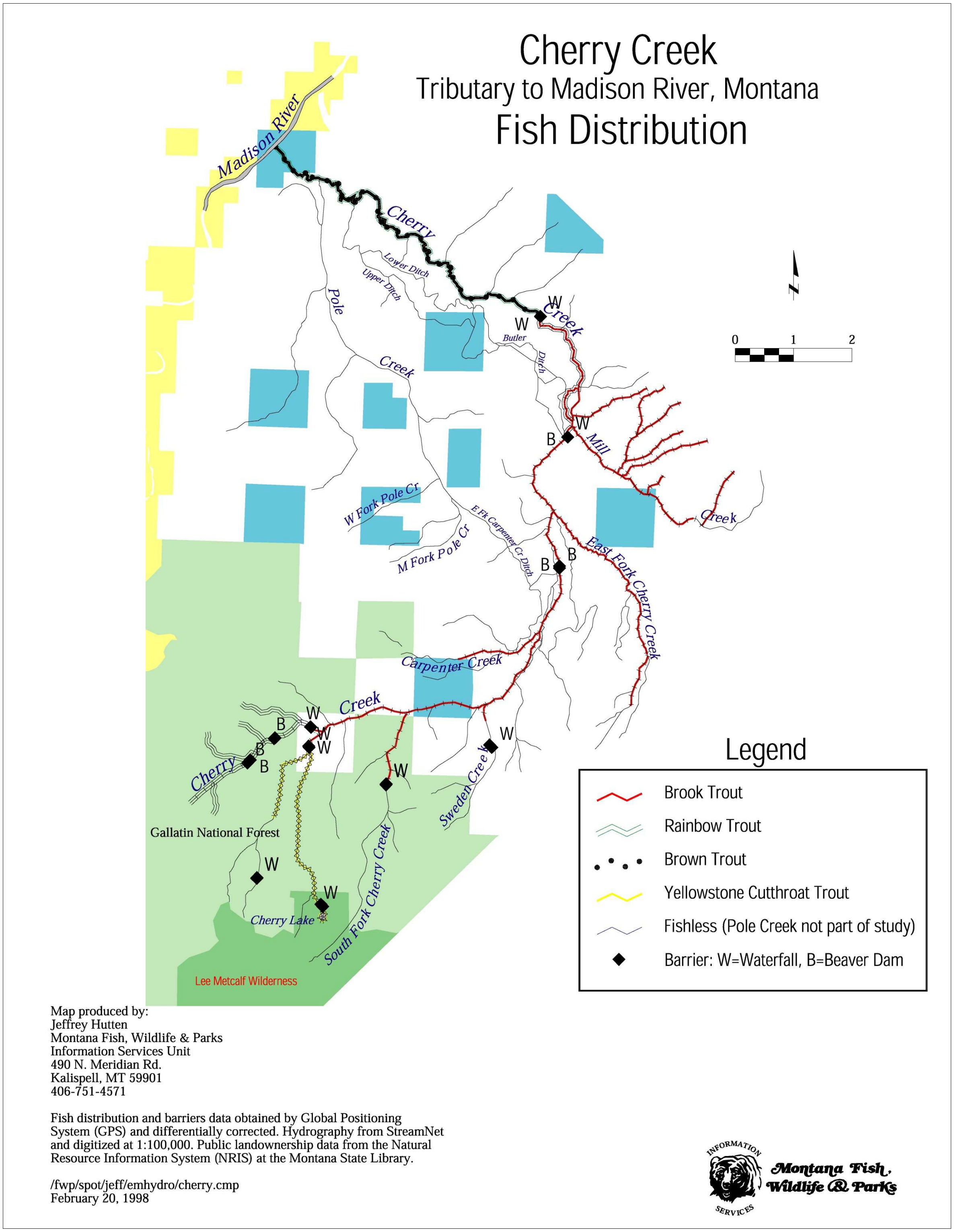


Figure 11. Cherry Creek Drainage. Landownership patterns have changed since this map was produced.

Table 2. Results of CFT Legumine rotenone bioassays in the East Fork of Cherry Creek to determine effective exposure time. Run time of the application station was 7 hours 52 minutes. CFT application was initiated at 09:33.

Sentinel fish station[1/]	Time of initial exposure	Time of 100% mortality	Hours of exposure til 100% mortality
30	10:03	10:50	0:47
60	10:33	12:55	2:22
90	11:03	12:55	1:52
120	11:33	14:00	2:27
150	12:03	14:55	2:52
180	12:33	16:15	3:42[2/]
210	13:03	16:15	2:48
240	13:33	NA[3/]	

[1/] Minutes of stream flow time downstream of CFT application station
[2/] 2 fish dead, 1 gravely ill at 1455 hrs (2:22 hours of exposure)
[3/] 100% mortality of sentinel fish was confirmed the following morning at 11:45

Figure 12. Trickle system and sentinel fish bag on Cherry Lake Creek. The sentinel fish bag is upstream of the CFT application point to monitor the effectiveness of the station above the one shown here.

Figure 13. Elbow & gate valve assembly.

Figure 14. Close-up view of the dog waterer trickling CFT/streamwater mixture into the stream during the Cherry Creek Project.

Figure 15. Remote streamside incubator (round bucket) and capture bucket (square bucket) in Cherry Creek

Figure 16. Photos of three sections of the West Madison Canal monitored for fish entrainment. Clockwise from top left – Eight-mile, Willow Ranch, and Range View Road.

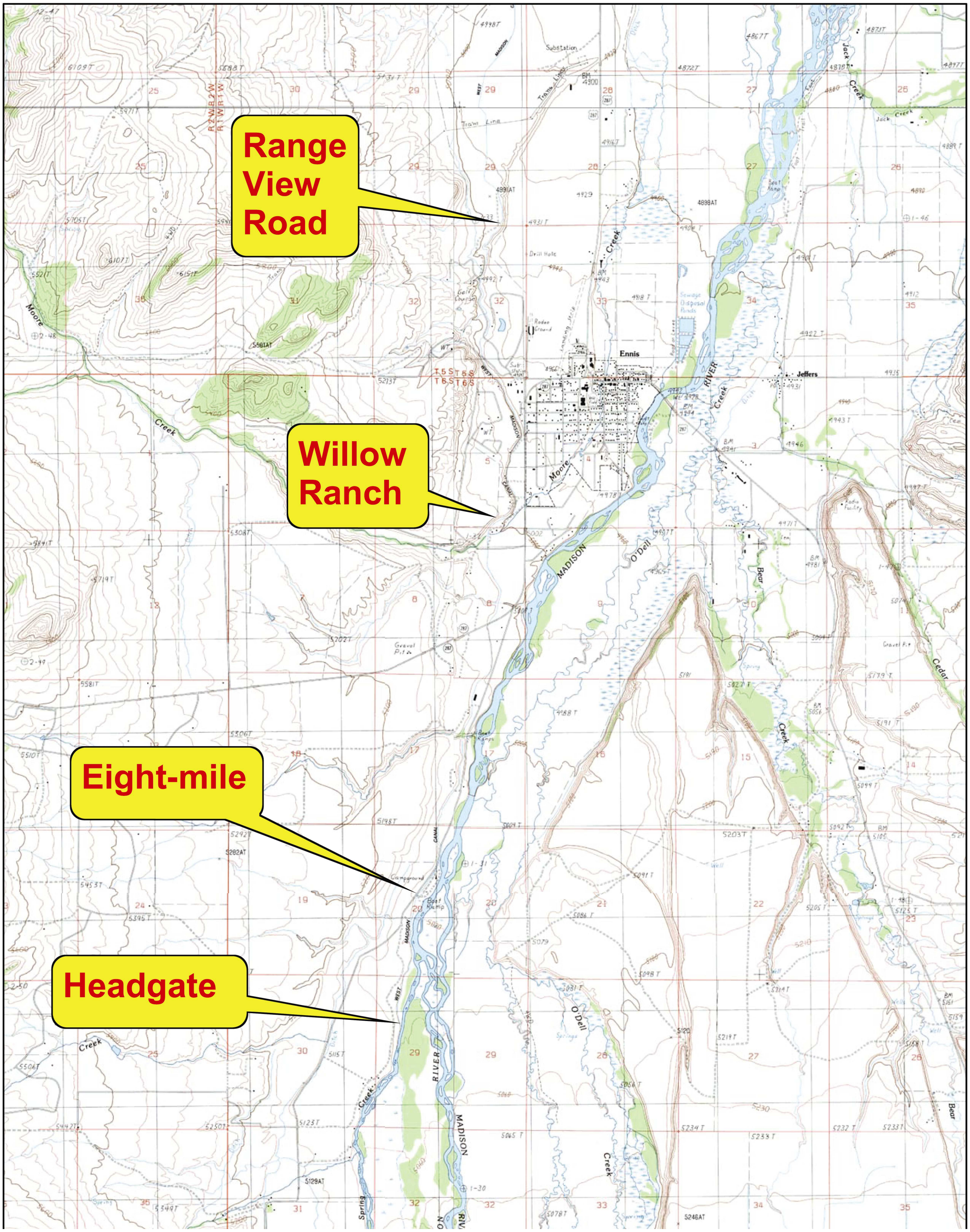


Figure 17. Locations of West Madison Canal fish entrainment monitoring sections.

RESULTS AND DISCUSSION

Madison Grayling

No young-of-the-year Arctic grayling were captured during beach seining in Ennis Reservoir 2007 (Appendix A). Shallow water in the south end of the reservoir prevented access to some standard monitoring sites, but seining was conducted in shallow areas where macrophytes were dense.

Arctic grayling require loose, recently scoured gravels and cobbles to broadcast their eggs over during spawning each spring (Byorth and Shepard 1990). Generally, normal spring runoff creates these conditions, but it is possible that winter and spring ice scour also make such conditions available. The duration and severity of the Madison River ice gorge (Figure 18) may affect the spawning success of the Ennis Reservoir grayling.

Anglers reported catching and releasing several grayling in July in the Madison River as far upstream as the Ruby Creek Campground, approximately 30 river miles upstream of Ennis Reservoir.

The USFWS re-evaluated the petition to list fluvial Arctic grayling as a Threatened species in light of a lawsuit filed in 2003 by the Center for Biological Diversity (CDB), concluding that listing Arctic grayling under the Threatened and Endangered Species Act was not warranted. A listing would have likely include all grayling populations regardless of behavioral traits or genetic similarity to Big Hole River fluvial grayling.

Madison grayling are genetically very similar to Big Hole fish, but exhibit adfluvial behavior. They reside in Ennis Reservoir all year except when they enter the Channels area of the Madison River in April to spawn, though periodically FWP receives reports of grayling in the Madison River as far as 30 miles upstream of Ennis Reservoir into the Fall.

MFWP has developed a Candidate Conservation Agreement with Assurance (CCAA) for fluvial Arctic grayling in the Big Hole Drainage. Landowners who sign onto the CCAA must develop and implement pro-active site-specific land management conservation measures in cooperation with agencies that will reduce or eliminate detrimental habitat conditions for the grayling. Despite the USFWS ruling that listing grayling is not warranted, landowners and irrigators continue to enroll in the program. Currently 33 landowners have enrolled 156,532 acres, with an additional 7,650 acres of State land enrolled.

Figure 18. The Madison River at the U.S. Highway 287 Bridge at Ennis, illustrating ice-gorged and ungorged conditions.

Gillnetting

Table 3 summarizes the 2007 gillnet data for Ennis Reservoir. As in previous years, Utah chub are the most abundant species, though the number captured is the lowest since monitoring began in 1995. No whitefish were captured in gillnetting in 2007.

Table 3. Summary of August 2007 gillnet catch in Ennis Reservoir. Length is in inches, weight is in pounds.

	UC[1]	WSu	LnSu	Rb	LL
Avg.length	8.7	13.1	10.7	17.6	18.2
Avg.weight	0.35	1.05	0.60	1.74	2.42
Number sampled	203	78	3	14	23

[1] UC = Utah Chub; WSu = White Sucker; LnSu = Longnose sucker; Rb = rainbow trout; LL = brown trout

Average length and weight of the most commonly captured species from 1995 – 2007 are illustrated in Appendix B.

Population Estimates

Population estimates were conducted in the Norris section in March and in the Pine Butte, Snoball and Varney sections in September (Figure 4).

Figures 19-22 illustrate population levels of six inch and larger rainbow trout per mile from 1995 – 2007 for the four estimate sections, and Figures 23-26 illustrate numbers six inch and larger of brown trout during the same time period. In 2007, the population of six-inch and larger rainbow trout in all monitoring sections were near their greatest abundance since 1995 when the impacts of whirling disease generally were the worst. Brown trout numbers also remained high in Pine Butte and Varney, while in the Norris section, they rebounded slightly from their 10-year low in 2006.

In 2005, FWP Regional Management personnel began reporting population numbers greater than six inches rather than using fish length to assign fish as yearling or two year old & older. Appendix C1 contains charts illustrating fish numbers as yearling and two year old & older fish per mile as reported in previous years of this report (MFWP 1995 – 2006). Appendix C2 contains historic total population levels of two year old & older rainbow and brown trout (+ 80% C.I.) for each section.

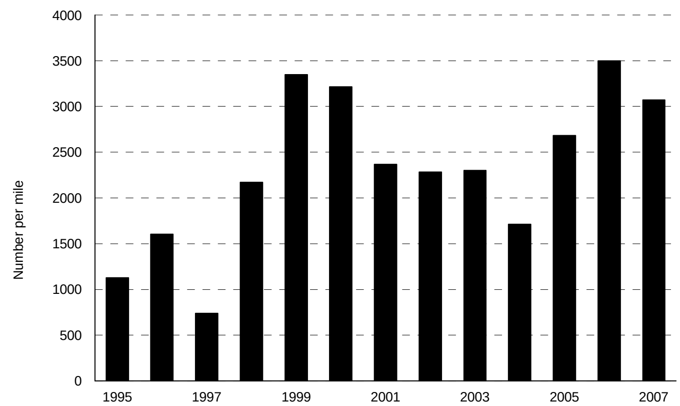


Figure 19. Rainbow trout ($\geq$ 6”) estimates in the Pine Butte section of the Madison River, 1995–2007, fall estimates.

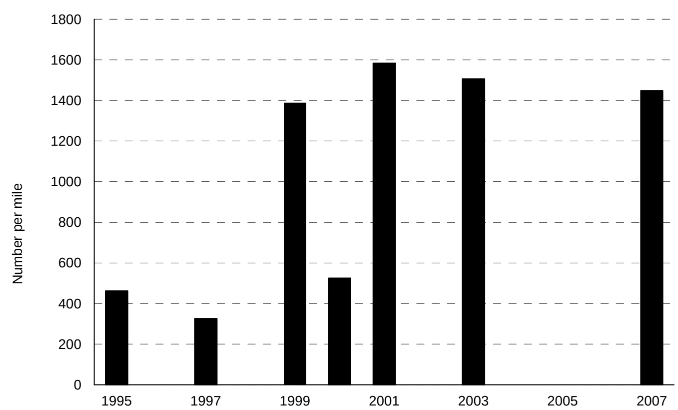


Figure 20. Rainbow trout ($\geq$ 6”) estimates in the Snoball section of the Madison River, 1995–2007, fall estimates.

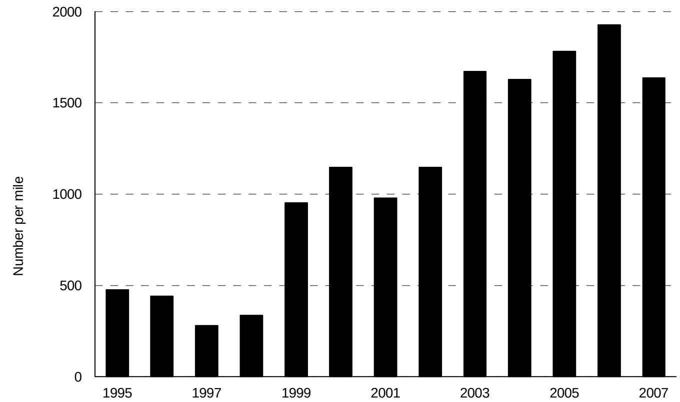


Figure 21. Rainbow trout (≥ 6”) estimates in the Varney section of the Madison River, 1995–2007, fall estimates.

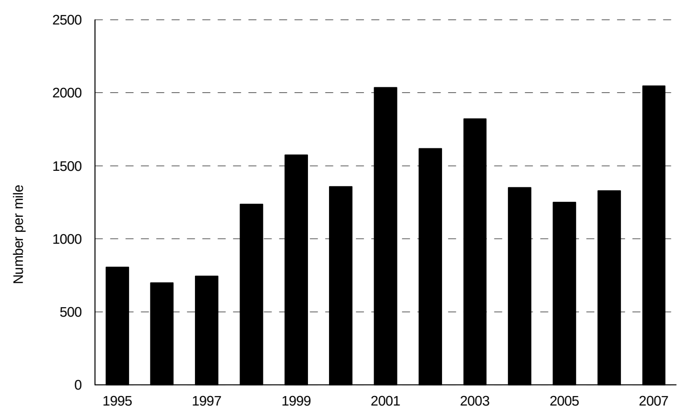


Figure 22. Rainbow trout (≥ 6”) estimates in the Norris section of the Madison River, 1995–2007, spring estimates.

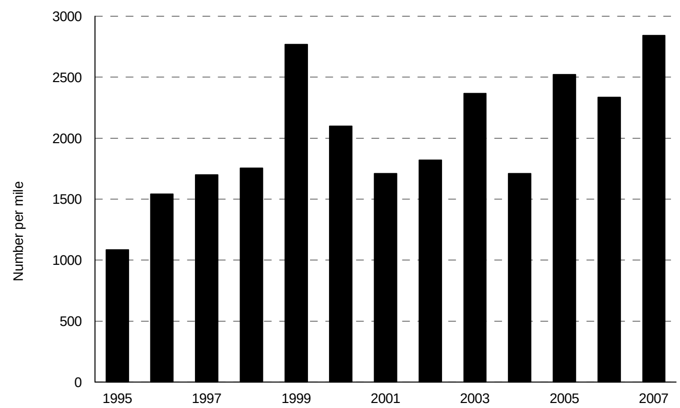


Figure 23. Brown trout (≥ 6”) estimates in the Pine Butte section of the Madison River, 1995–2007, fall estimates.

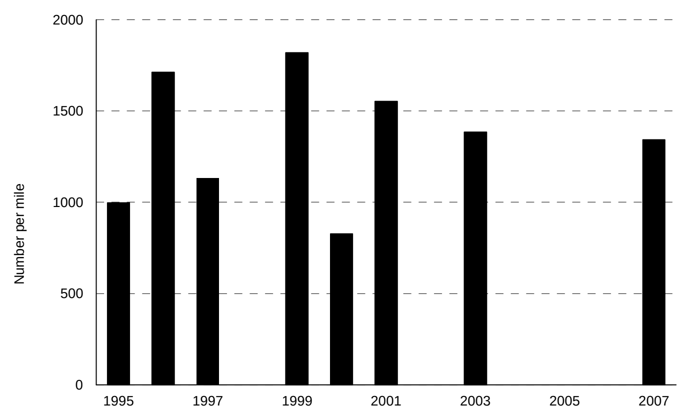


Figure 24. Brown trout (≥ 6”) estimates in the Snoball section of the Madison River, 1995–2007, fall estimates.

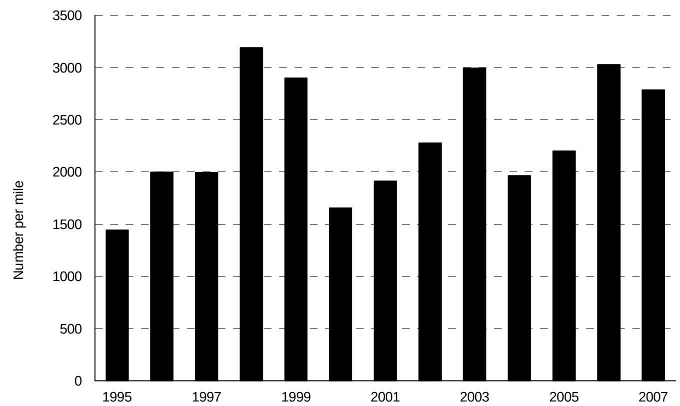


Figure 25. Brown trout (≥ 6") estimates in the Varney section of the Madison River, 1995–2007, fall estimates.

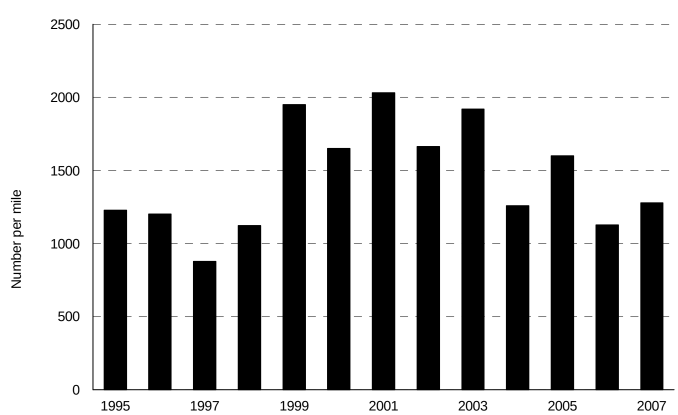


Figure 26. Brown trout (≥ 6") estimates in the Norris section of the Madison River, 1995–2007, spring estimates.

River Discharge

In 1994 PPL Montana implemented a pulse flow system on the Madison River downstream of Ennis Reservoir in years of high water temperature to prevent thermally induced fish kills. Despite being developed as a stop-gap measure for extremely warm and dry years, pulse flows have been conducted for 8 consecutive years. Table 4, adapted from PPL Montana data, summarizes statistics regarding pulse flows in the Madison in years pulsing was conducted.

Table 4. Summary statistics for years in which pulse flows were conducted on the Madison River.

Year	Hebgen October 1 pool elevation[1/]	Feet below full pool	Feet of Hebgen draft due to pulsing	Number of days pulsing occurred
2000	6531.21	3.66	0.61	29
2001	6530.53	4.34	0.05	13
2002	6530.46	4.41	0.70	18
2003	6528.59	6.28	2.68	39
2004	6532.07	2.8	0.28	12
2005	6531.52	3.35	0.30	17
2006	6530.86	4.01	1.74	15
2007	6526.05	8.82	2.12	43

[1/] Hebgen full pool is 6534.87 msl. The FERC license requires PPL Montana to maintain Hebgen pool elevation between 6530.26 and 6534.87 from June 20 through October 1.

Flushing flows did not occur in the Madison River in 2007. The combination of Hebgen Reservoir storage volume and runoff forecast was below trigger volumes. In fact, runoff was so poor in 2007 that Hebgen Reservoir did not maintain the license mandated June 20 – October 1 minimum pool elevation of 6530.26, necessitating a 4.21 foot drawdown below the October 1 minimum pool elevation.

Temperature Monitoring

Optic StowAway temperature recorders were deployed throughout the Madison River to document air and water temperatures (Figure 6). Table 6 summarizes the data collected at each location in 2007. Appendix D1 contains thermographs for each location, Appendix D2 contains thermographs at selected locations showing the 24-hour diurnal temperature fluctuation of each site around the warmest date of the year.

Aquatic Nuisance Species

The annual economic cost of invasive species management and control in the United States is estimated to be nearly $120 billion (Pimentel et al 2005). It is estimated that about 42% of the species on the Threatened or Endangered species lists are at risk primarily because of alien-invasive species.

Table 6. Maximum and minimum temperatures (^oF) at selected locations in the Madison River Drainage, 2007. Air and water temperature data were recorded every 30 minutes from April 28 –October 10 (7944 readings). Thermographs for each location are in Appendix D1.

	Site	Max	Min
Water	Hebgen inlet	80.74	44.77
	Hebgen discharge	67.74	38.07
	Quake Lake inlet	68.36	37.31
	Quake Lake outlet[1/]	63.03	49.55
	Kirby Bridge	71.86	37.28
	McAtee Bridge	73.44	37.61
	Ennis Bridge	76.19	40.13
	Ennis Reservoir Inlet	80.05	39.96
	Ennis Dam	76.51	44.91
	Bear Trap Mouth	79.09	43.27
	Norris	80.30	42.97
	Blacks Ford	80.31	41.81
	Cobblestone	81.93	42.38
	Headwaters S.P. (Madison mouth)	82.08	45.08
Air	Kirkwood Store	100.56	25.88
	Slide	100.72	32.16
	Wall Creek HQ	96.85	26.26
	Ennis	100.74	27.35
	Ennis Dam	97.83	31.70
	Norris	100.79	29.84
	Cobblestone	94.62	27.15

[1/] The original Quake outlet data recorder ceased operating between June 19 & August 23, its data was not recoverable. A replacement data recorder was deployed August 24. It is likely the maximum annual temperature at this site was not recorded.

In 1994, two invasive species were detected in the Madison Drainage – New Zealand mudsnails (*Potamopyrgus antipodarum*) and whirling disease (*Myxobolus cerebralis*). Montana has an active multi-agency ANS program coordinated through FWP (Appendix E).

New Zealand Mudsnails

Montana's ANS crew sampled for NZMS at numerous sites on the Madison River between Varney and Greycliff FASs. All sites were positive, but densities were at their lowest level since initial detection.

The Montana Aquatic Species Coordinator has developed a plan to address New Zealand mudsnails. Specifically, these actions include:

1) Listing New Zealand mudsnails as a Prohibited species in Montana.
2) Assisting in development of a regional management plan for New Zealand mudsnails, an important portion of which will describe actions to be undertaken when New Zealand mudsnails are found in or near a hatchery.
3) Establishing statewide monitoring efforts.
4) Conducting boat inspections at popular FAS, many of which are on the Madison River. This effort assists with public education/outreach and also ensures boats are not spreading New Zealand mudsnails or other ANS.
5) Purchasing portable power washing systems for cleaning boats and trailers at fishing access sites.

The MFWP Fisheries office in Ennis uses a power washer to clean project equipment to reduce the chance of spreading ANS through work activities.

NZMS have been detected in one private hatchery, but have not been found in any state or federal hatcheries. Strategies have been implemented to prevent the spread of NZMS from the private hatchery. The spread of New Zealand mudsnails has slowed and appears to be confined to east of the Continental Divide.

Additional information on Aquatic Nuisance Species is on the web at www.anstaskforce.gov and www.protectyourwaters.net, and for New Zealand mudsnails specifically, is available at www.esg.montana.edu/aim/mollusca/nzms.

Whirling Disease

Caged young-of-the-year rainbow trout in the Madison River continue to exhibit high infection rates & severity, with average spring and early summer histology scores exceeding 4.0 according to the MacConnell- Baldwin Scale (Appendix F). However, the juvenile rainbow trout used in the sentinel cage studies are not offspring of Madison River rainbow trout, but are from the captive stock that has been used in sentinel cages since studies began in 1996. The high infection rate exhibited by this captive stock shows that whirling disease is still at high levels in the Madison River, but offspring of Madison River rainbow trout appear to be developing a resistance to whirling disease as evidenced by rainbow trout population estimates in the upper river (Figures 19-22). In 1998, and again in 2004, eggs were collected from spawning rainbow trout near the Slide Inn below Quake Lake and the resulting fry exposed to a controlled number of TAMs in the Wild Trout Laboratory in Bozeman. Fry from the 2004 spawners exhibited a lower proportion of fish in the highly infective categories compared to those from 1998 (Figure 27). For rainbow trout, average histology scores above 2.5 are associated with high mortality of young-of-the-year and significant decreases in population. In Figure 27, the average histology score of the 1998 test fish is 4.13, while that of the 2004 test fish is 2.42.

Vincent (2007) speculates that high levels of whirling disease spores persist in the Madison River because some rainbow trout produced in the late 90's through early 2000's still survive in the river, and their offspring are not resistant. He further speculates that as those older fish fall out of the spawning population, only fish that have developed resistance to whirling disease will remain, and the number of whirling disease spores in the river will diminish.

Information on whirling disease, including numerous links, is available online at www.whirling-disease.org.

Westslope Cutthroat Trout Conservation and Restoration

Habitat projects conducted by the Madison Ranger District of the Beaverhead-Deerlodge National Forest are summarized in Appendix G.

Sun Ranch Westslope Cutthroat Trout Program

Four female and 9 male Sun Ranch brood fish were spawned in 2007, producing 3,075 eyed eggs for introduction into Cherry Creek and 396 fry for introduction into the from Sun Pond. Additionally, approximately 544 fry produced from eggs taken at three streams in 2007 were introduced into the Sun Pond in 2007.

Cherry Creek Native Fish Introduction Program

Over 14,200 westslope cutthroat eggs from three wild donor stream, the Sun Ranch brood, and the Washoe Park Hatchery were reared to the eyed stage then placed in RSI's (Figure 15) in both forks of Phase 1 in 2007 (Figure 28). A total of 10,007 eggs were from the three wild streams, 3,075 from the Sun Ranch brood (which is comprised of donors from two of the wild streams used in 2007 as well as five additional wild streams since 2002) and 1,121 from the Washoe Park Hatchery.

Personnel from MFWP, Montana State University, Gallatin National Forest, and Turner Enterprises spent approximately 264 worker-days completing the project in 2007, including all preparatory and support activities and treatments. A total of 6.90 gallons of CFT were required to complete treatments in 2007, all in Cherry Creek and tributaries.

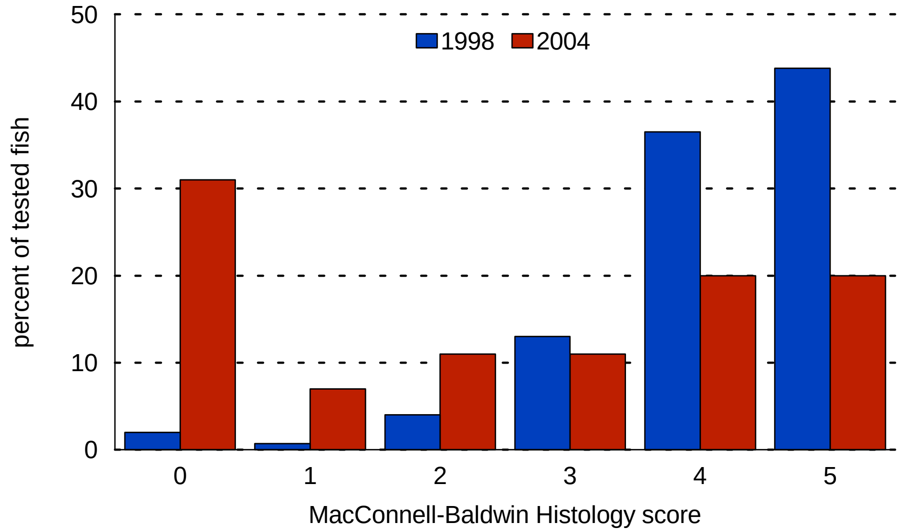


Figure 27. Percentage of young-of-the-year Madison River rainbow trout within MacConnell-Baldwin histology ratings in 1998 and 2004. See Appendix F for MacConnell-Baldwin definitions.

Fish Entrainment

The WMC draws water from the river on the west bank of the western river channel approximately one mile upstream of the Eight-mile Fishing Access Site, and has been observed for fish entrainment since 2001. Surveys were limited in 2002 & 2003 as ice-up occurred prior to the ditch being shut down for the year, so ice cover concealed stranded fish. In years when the WMC headgate was closed prior to ice-up, several hundred or more fish, primarily trout, were observed stranded in the ditch and were lost to the population. It is unlikely that preventing those trout from becoming entrained in the ditch would increase the river population by that same number of fish due to competition, predation, and angling harvest that would occur in the river. The trout population below Varney is dominated by brown trout, and most fish observed in the ditch are brown trout. In recent years local anglers, interested citizens, and the Madison River Foundation (ennisflyfishing.com) were granted permission by the WMC water users and FWP to conduct a fish salvage effort. In 2005, approximately 2,000 fish were captured in hand held nets or other devices and returned to the river after the headgate was closed and the ditch water receded. In 2006, a similar effort salvaged fewer fish, approximately 1,200, due mainly to thick ice cover that formed and lead to a quick shutdown of the ditch. The thick ice cover made locating and capturing fish difficult. Species captured include brown and rainbow trout, mottled sculpin, longnose dace, and juvenile whitefish and white suckers (Figure 29).

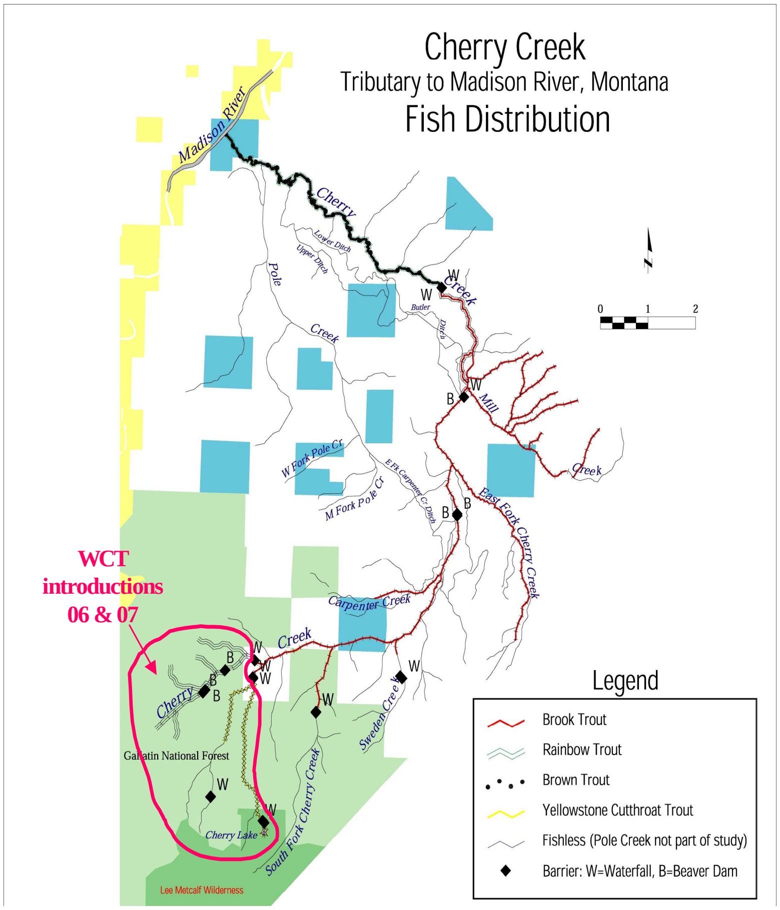


Figure 28. Phase 1 of Cherry Creek Native Fish Introduction Project where westslope cutthroat trout were introduced in 2006 & '07 following eradication of non-native Yellowstone cutthroat and rainbow trout in 2003 – 2005.

Figure 29. A sample of fish salvaged from the West Madison Canal and released into the Madison River.

In 2007, WMC water right holders allowed FWP access to the ditch to actively monitor fish entrainment. Each of three 500-foot sections were surveyed with electrofishing eight times during the season. A significant increase in entrainment occurred between mid-July and mid-August in each of the two upstream sections, 8-Mile and Willow Ranch, and to a lesser degree in the downstream Range View Road section between mid-August and early September. The 8-mile section showed increasing numbers of fish throughout the season, the number of fish in the Willow Ranch section peaked in August and then decreased through mid October, and the number of fish in the Range View Road section remained low and steady after early September (Figure 30). Figures in Appendix H show species composition and rate of entrainment by date for each of the three sections. Figure 31 illustrates the proportion of brown trout, rainbow trout, and whitefish by size class on the final sample date in October.

Several methods that reduce or eliminate stranding are available. Screening is one option, but it is very expensive and in some locations has not worked as well as anticipated. Another method is to incrementally close the headgate over several days, which slowly reduces the volume of water in the ditch, prompting many fish to move upstream, exiting the ditch and returning to the river prior to complete closure of the headgate. This method has been used successfully on the Granger (Storey) Ditch for several years (Mel McKittrick, 2004, pers.comm.). The incremental shutdown method is also employed in effect on the WMC because as the irrigation season is completed, water flow into the ditch is reduced to a volume that will satisfy stockwater rights, which is less than the volume necessary for irrigation. During 2008, with cooperation and support of the Ennis National Fish Hatchery, FWP will experiment with a bubbling method, which may be less expensive than screening, to determine its feasibility for use in the WMC.

CONCLUSIONS AND FUTURE PLANS

The Madison (Ennis) Reservoir grayling population continues to persist at low levels. While the Madison population is very similar genetically to the Big Hole population, it exhibits an adfluvial life history pattern versus the fluvial behavior of the Big Hole River population.

Rainbow and brown trout gillnet catch has increased in Ennis Reservoir since 1995 while the number of Utah chub captured has decreased. Despite this, Utah chub are still the most abundant species captured in the reservoir by nearly an order of magnitude.

Population estimates will continue to be conducted annually in the Madison River. These data are necessary for setting angling regulations, and to monitor environmental and biological impacts on the populations.

Poor snowpack and low runoff in 2007 resulted in failure to achieve full pool in Hebgen Reservoir as well as the most intensive pulse flow year since the program was implemented.

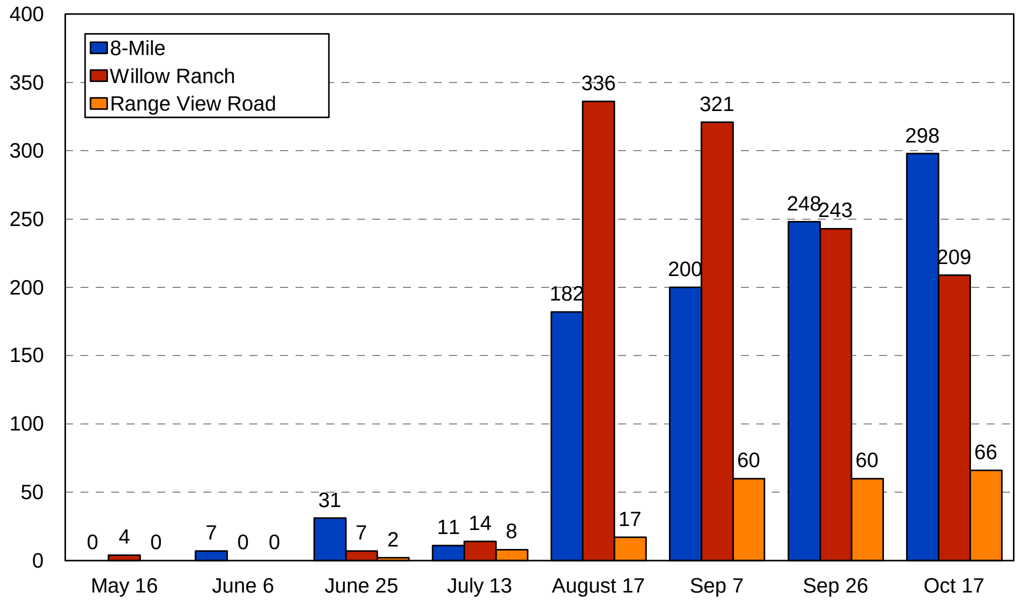


Figure 30. Number of fish captured (all species combined) by sample date in three sections of the West Madison Canal in 2007.

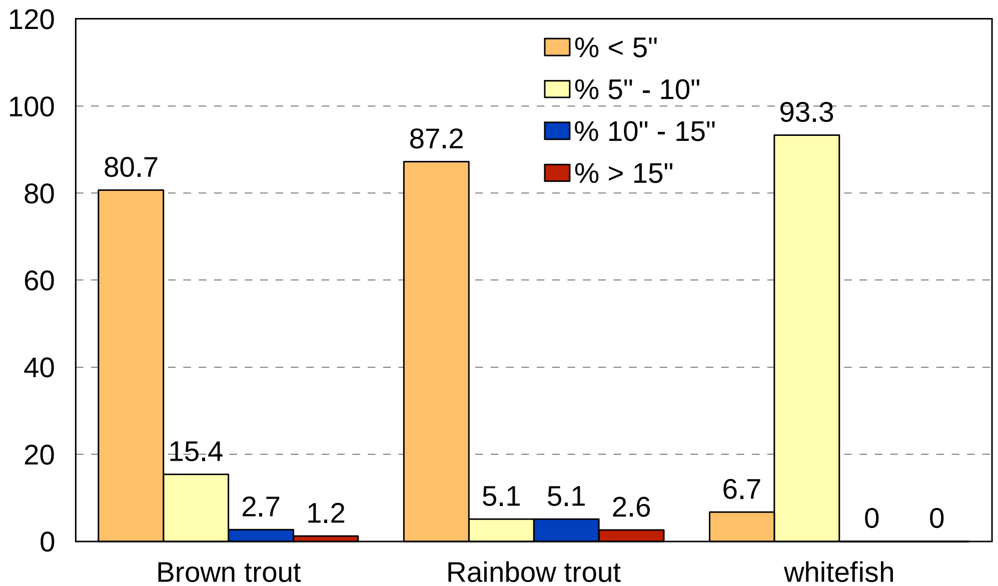


Figure 31. Proportion of brown trout, rainbow trout, and mountain whitefish by size class in three sections of the West Madison Canal in October, 2007.

New Zealand Mudsnail populations will continue to be monitored through the 2188 Biological and Biocontaminant monitoring program and through the FWP Aquatic Nuisance Species Program.

Sentinel cage rainbow trout deployed in the Madison River have continued to show high infection rates and severity, and since 2002 sites previously known to have low infection severity have shown increasing severity. In laboratory studies, progeny of Madison River rainbow trout are exhibiting resistance to whirling disease.

FWP has implemented a program and provided equipment to clean sampling gear to reduce the chance of moving ANS between waters.

In 2007, adult WCT from the Sun Pond were spawned and resulting fry stocked back into the pond. Wild donor populations will continue to be tapped for the next several years as well for replicating existing wild, genetically pure WCT populations into fishless streams to expand the range and numbers of WCT, thereby diminishing their extinction risk.

The Cherry Creek Native Fish Introduction Project will continue in 2008. The second treatment of Phase 3 will be conducted. The third year of WCT introductions will be conducted in Phase 1 of the project area, and introductions will be initiated in Phase2.

Surveys of fish entrainment in irrigation ditches will continue in 2008, though at a reduced level. Surveys will be conducted several times through the irrigation season to confirm the 2007 results, and methods to reduce entrainment will be tested at the Ennis National Fish Hatchery.

LITERATURE CITED

Bramblett, R.G. 1998. Environmental Assessment. Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program: Cherry Creek Native Fish Introduction. Prepared for Montana Fish, Wildlife, & Parks, April 15, 1998. 70 pages.

Byorth, P. 2004. Hebgen Reservoir Creel Survey and Contribution of Stocked Rainbow Trout to the Recreational Fishery: June 2000 to June 2001. 25 pages.

Byorth, P. and B. Shepard. 1990. Ennis Reservoir/Madison River Fisheries Investigations. Montana Fish, Wildlife, & Parks Final Report to Montana Power Company. 90 pages.

Federal Energy Regulatory Commission. 2000. Order Issuing New License, Project No. 2188-030. Issued September 27, 2000.

Hetrick, N. J. 1993. Cooperative Study on Fish Migration and Spawning in the Upper Madison River Drainage *Annual Report*: April 1993. 20 pages.

Jeanes, E. D. 1996. Behavioral Responses to Water Current of Age 0 Arctic Grayling from the Madison River, and Their Use of Stream Habitat. MS Thesis, Montana State University-Bozeman, August 1996. 60 pages.

Leary, R. 1990. Letter to MFWP Biologist Pat Byorth. University of Montana Wild Trout & Salmon Genetics Laboratory, Division of Biological Sciences, Missoula, MT. September 1990.

McKittrick, M. 2004. Personal communication.

Montana Department of Natural Resources and Conservation. 1979. River Mile Index of the Missouri River. Water Resources Division.

Montana Fish, Wildlife, & Parks. 1995. Madison River/Ennis Reservoir Fisheries. 1994 Annual Report to Montana Power Company, Environmental Division, Butte, from Montana Fish, Wildlife, & Parks, Pat Clancey, Ennis. May 1995.

Montana Fish, Wildlife, & Parks. 1996. Madison River/Ennis Reservoir Fisheries. 1995 Annual Report to Montana Power Company, Environmental Division, Butte, from Montana Fish, Wildlife, & Parks, Pat Clancey, Ennis. February 1996.

Montana Fish, Wildlife, & Parks. 1997. Madison River/Ennis Reservoir Fisheries. 1996 Annual Report to Montana Power Company, Environmental Division, Butte, from Montana Fish, Wildlife, & Parks, Pat Clancey, Ennis. March 1997.

Montana Fish, Wildlife, & Parks. 1998a. Madison River/Ennis Reservoir Fisheries. 1997 Annual Report to Montana Power Company, Environmental Division, Butte, from Montana Fish, Wildlife, & Parks, Pat Clancey, Ennis. June 1998.

Montana Fish, Wildlife, & Parks. 1998b. Decision Notice: Cherry Creek Native Fish Introduction Project. Region 3, July 6, 1998. Pat Clancey. 30 pages.

Montana Fish, Wildlife, & Parks. 1999a. Madison River/Ennis Reservoir Fisheries and Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program. 1998 Annual Report to Montana Power Company, Environmental Division, Butte, and Turner Enterprises, Inc., Gallatin Gateway, from Montana Fish, Wildlife, & Parks, Pat Clancey, Ennis. April 1999.

Montana Fish, Wildlife, & Parks. 1999b. Memorandum of Understanding and Conservation Agreement for Westslope Cutthroat Trout in Montana. May 1999.

Montana Fish, Wildlife, & Parks. 2000. Madison River/Ennis Reservoir Fisheries and Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program. 1999 Annual Report to PPL Montana (formerly Montana Power Company), Environmental Division, Butte, and Turner Enterprises, Inc., Gallatin Gateway, from Montana Fish, Wildlife, & Parks, Pat Clancey, Ennis. April 2000.

Montana Fish, Wildlife, & Parks. 2001. Madison River/Ennis Reservoir Fisheries and Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program. 2000 Annual Report to PPL Montana, Environmental Division, Butte, and Turner Enterprises, Inc., Gallatin Gateway, from Montana Fish, Wildlife, & Parks, Pat Clancey and Dan Downing, Ennis. April 2001.

Montana Fish, Wildlife, & Parks. 2002. Madison River/Ennis Reservoir Fisheries and Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program. 2001 Annual Report to PPL Montana, Environmental Division, Butte, and Turner Enterprises, Inc., Gallatin Gateway, from Montana Fish, Wildlife, & Parks, Pat Clancey, Ennis. June 2002.

Montana Fish, Wildlife, & Parks. 2003. Madison River/Ennis Reservoir Fisheries and Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program. 2002 Annual Report to PPL Montana, Environmental Division, Butte, and Turner Enterprises, Inc., Gallatin Gateway, from Montana Fish, Wildlife, & Parks, Pat Clancey, Ennis. March 2003.

Montana Fish, Wildlife, & Parks. 2004a. Madison River/Ennis Reservoir Fisheries and Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program. 2003 Annual Report to PPL Montana, Environmental Division, Butte, and Turner Enterprises, Inc., Gallatin Gateway, from Montana Fish, Wildlife, & Parks, Pat Clancey, Ennis. May 2004.

Montana Fish, Wildlife, & Parks. 2004b. FA+. Montana Fish, Wildlife, & Parks, Information Services Unit, Bozeman.

Montana Fish, Wildlife, & Parks. 2005. Madison River/Ennis Reservoir Fisheries and Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program. 2004 Annual Report to PPL Montana, Environmental Division, Butte, and Turner Enterprises, Inc., Gallatin Gateway, from Montana Fish, Wildlife, & Parks, Pat Clancey & Travis Lohrenz, Ennis. April 2005.

Montana Fish, Wildlife, & Parks. 2006. Madison River/Ennis Reservoir Fisheries and Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program. 2004 Annual Report to PPL Montana, Environmental Division, Butte, and Turner Enterprises, Inc., Gallatin Gateway, from Montana Fish, Wildlife, & Parks, Pat Clancey, Ennis. June 2007.

Montana Fish, Wildlife, & Parks. 2007. Madison River/Ennis Reservoir Fisheries and Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program. 2004 Annual Report to PPL Montana, Environmental Division, Butte, and Turner Enterprises, Inc., Gallatin Gateway, from Montana Fish, Wildlife, & Parks, Pat Clancey, Ennis. June 2008.

Pimentel, D., R. Zuniga, and D. Morrison. 2005. Update on the environmental and economic costs associated with alien-species in the United States. Ecological Economics, 2005 (Vol. 52) (No. 3) 273-288

Sloat, M.R., B.B. Shepard, and P. Clancey. 2000. Survey of tributaries to the Madison River from Hebgen Dam to Ennis, Montana with an emphasis on distribution and status of westslope cutthroat trout. Report to Montana Fish, Wildlife, & Parks, Helena, Montana. 165 pages.

Staigmiller, Ken. 2007. Personal Communication.

Vincent, Dick. 2007. Personal Communication.

Watschke, Darin. 2006. Assessment of Tributary Potential for Wild Rainbow Trout Recruitment in Hebgen Reservoir, Montana. Master of Science Thesis, Montana State University, Bozeman, MT. 139 pages.

Appendix A1

Summary of Ennis Reservoir beach seining 1995 - 2007

Species abbreviations:

AG Arctic grayling
MWF mountain whitefish
LL brown trout
Rb rainbow trout

Date	AG	MWF	LL	Rb
7/27/95	12	177	4	0
9/1/95	23	89	4	0
6/18/96	0	6	1	2
7/22/96	0	0	0	0
8/22/96	0	0	1	0
8/20/97	1	0	3	0
10/27/97	0	5	0	0
9/4/98	0	0	0	0
9/22/99	2	34	0	0
11/2/00	0	14	3	0
8/29/01	0	0	0	0
10/2/02	1	2	4	0
10/6/03	0	2	3	1
9/28/04	1	9	96	0
9/27/05	0	11	19	5
11/5/07	0	0	0	0

Appendix A2

Description of young-of-the-year Arctic grayling beach seining locations in Ennis Reservoir, and catch at each site. See Figure 3 for site locations.

Species abbreviations:

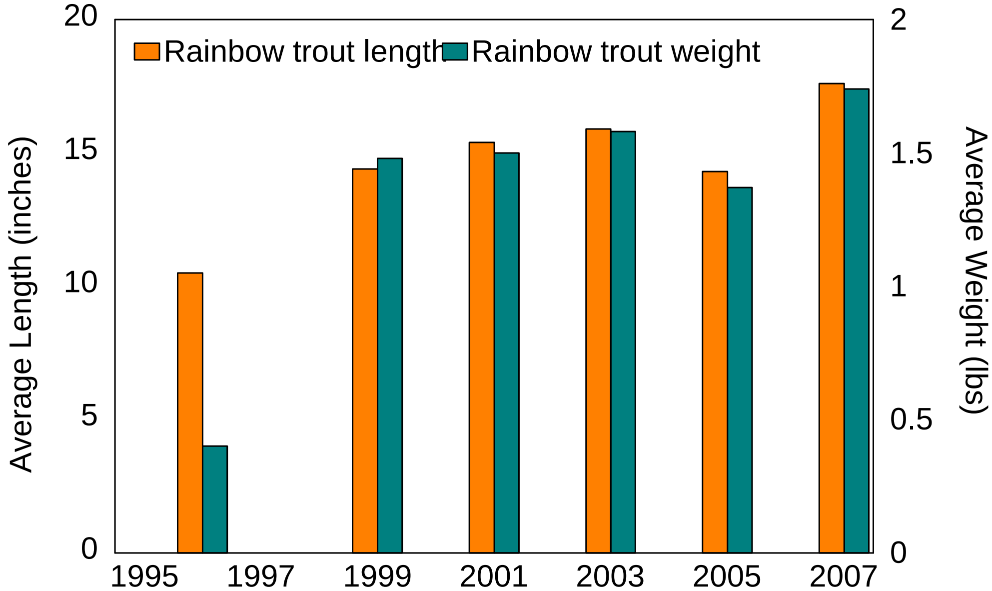
AG Arctic grayling
MWF mountain whitefish
WSu white sucker
UC Utah chub

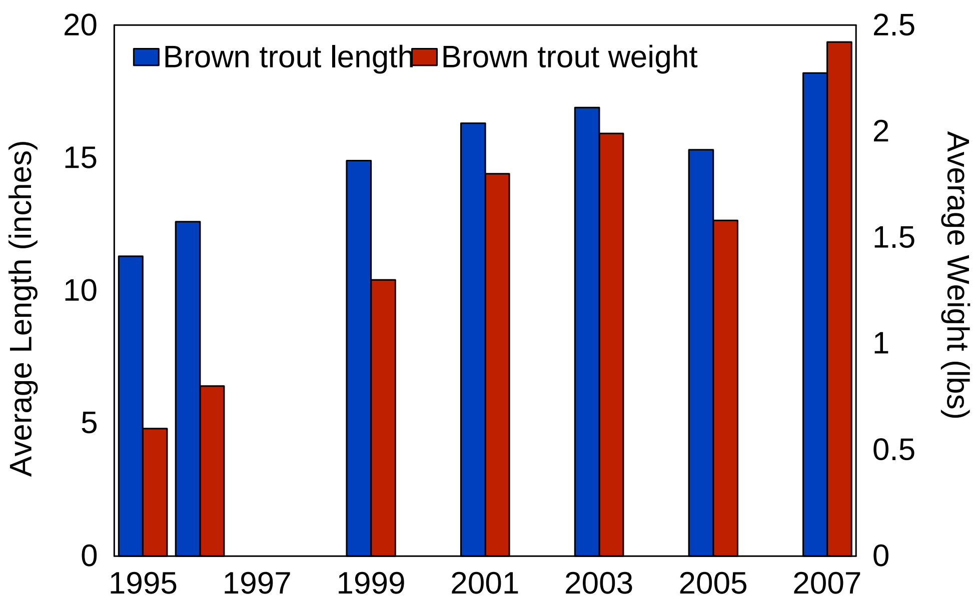
November 5, 2007

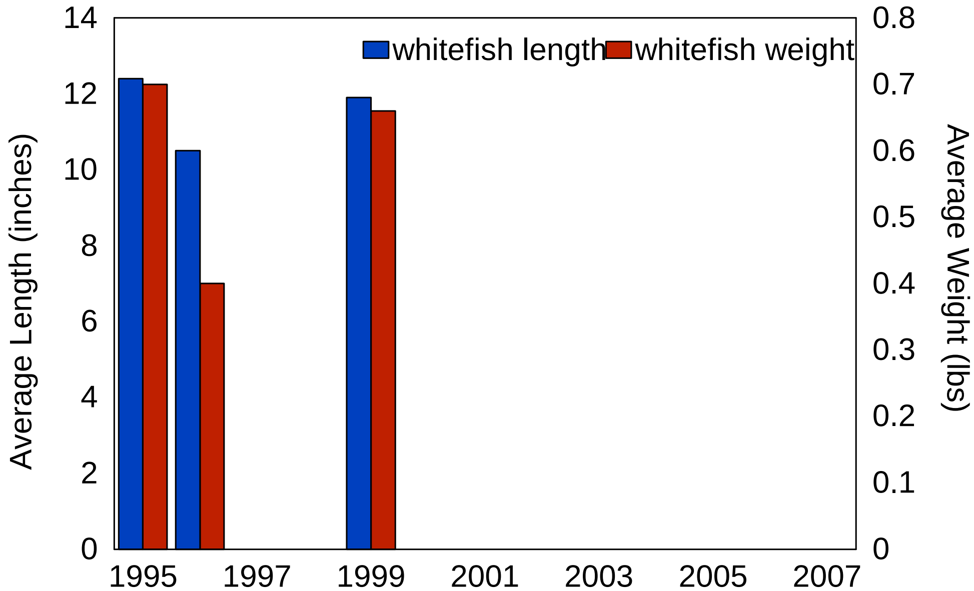
Site and time seined	AG	MWF	Note
Meadow Ck FAS North shore willows 1045 hrs Fig 3 site 1	0	0	Few macrophytes; 2 juvenile UC, 3 juvenile WSu
Meadow Ck FAS West shore willows 1100 hrs Fig 3 site	0	0	Few macrophytes 4 juvenile UC 4 juvenile WSu
500 yards east of Clutes Landing 1130 hrs Fig 3 site 2	0	0	Abundant macrophytes; 6 juvenile UC 3 juvenile WSu
1000 yards east of Clutes Landing 1215 Fig 3 site 3	0	0	Abundant macrophytes; 27 juvenile UC 46 juvenile WSu

Appendix B

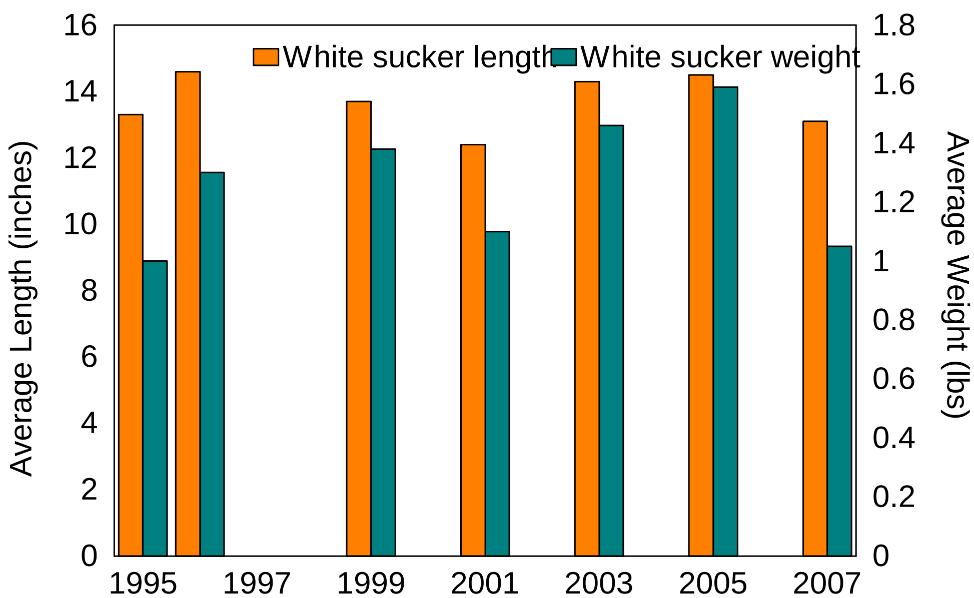
Ennis Reservoir Gillnet Trend
1995 – 2007

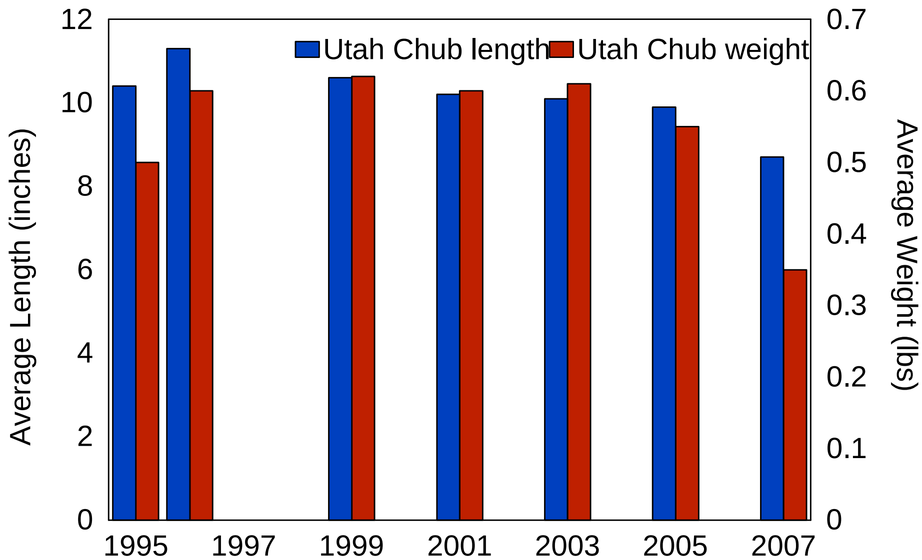

Rainbow trout length
Rainbow trout weight
Average Length (inches)
Average Weight (lbs)
20
15
10
5
0
2
1.5
1
0.5
0
1995
1997
1999
2001
2003
2005
2007


Brown trout length
Brown trout weight
Average Length (inches)
Average Weight (lbs)
20
15
10
5
0
2.5
2
1.5
1
0.5
0
1995
1997
1999
2001
2003
2005
2007



No whitefish have been captured in Ennis Reservoir gillnetting since 1999





Utah Chub length
Utah Chub weight
Average Length (inches)
Average Weight (lbs)
0
2
4
6
8
10
12
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
1995
1997
1999
2001
2003
2005
2007

Appendix C1

Historic population estimates of aged rainbow and brown trout per mile in the Pine Butte, Snoball, Varney, and Norris sections of the Madison River

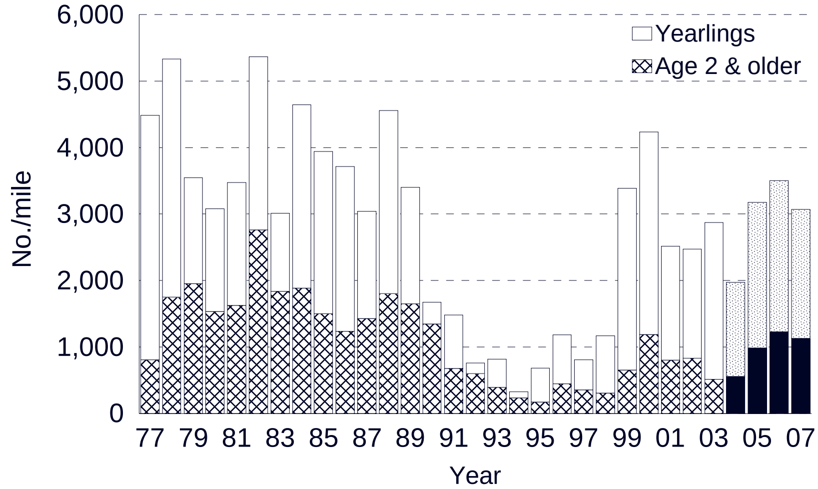


Figure B1 - 1. Rainbow trout populations in the Pine Butte section of the Madison River, 1977-2007, fall estimates. Estimates for 2004 - 2007 are not aged.

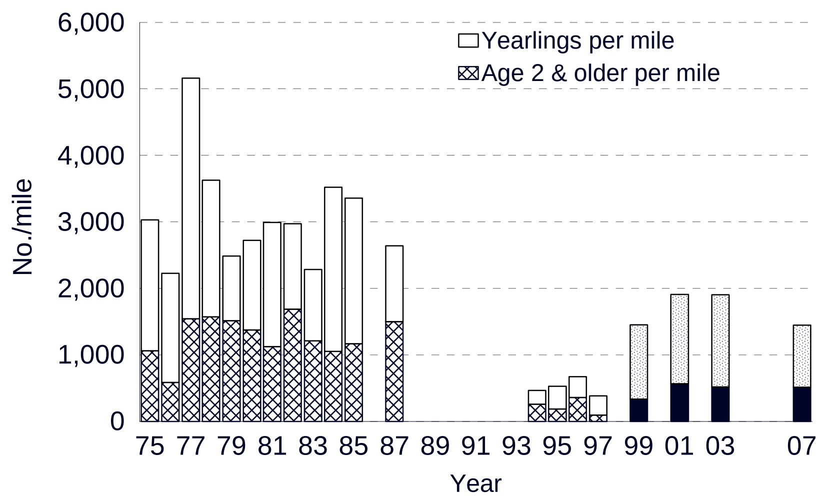


Figure B1 – 2. Rainbow trout populations in the Snoball section of the Madison River, 1975-2007, fall estimates. Estimates for 1999 - 2007 are not aged.

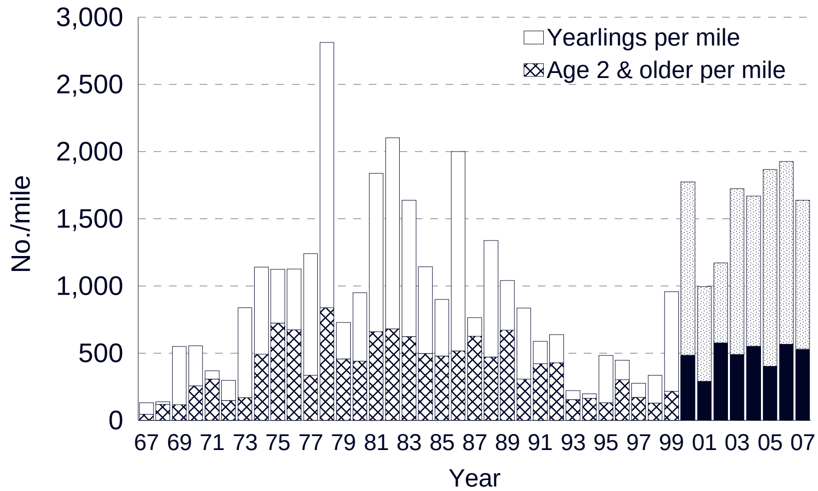


Figure B1 – 3. Rainbow trout populations in the Varney section of the Madison River, 1967-2007, fall estimates. Estimates for 2000 - 2007 are not aged.

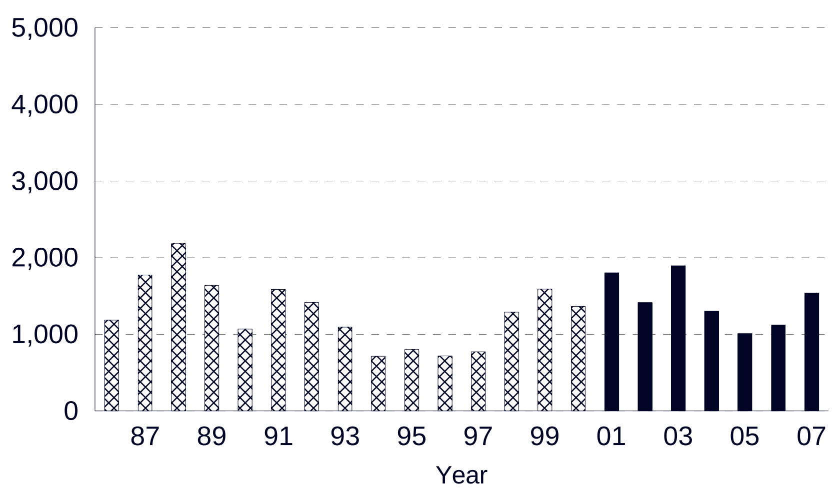


Figure B1 – 4. Rainbow trout populations in the Norris section of the Madison River, 1986-2007, spring estimates. Estimates for 2001 - 2007 are not aged.

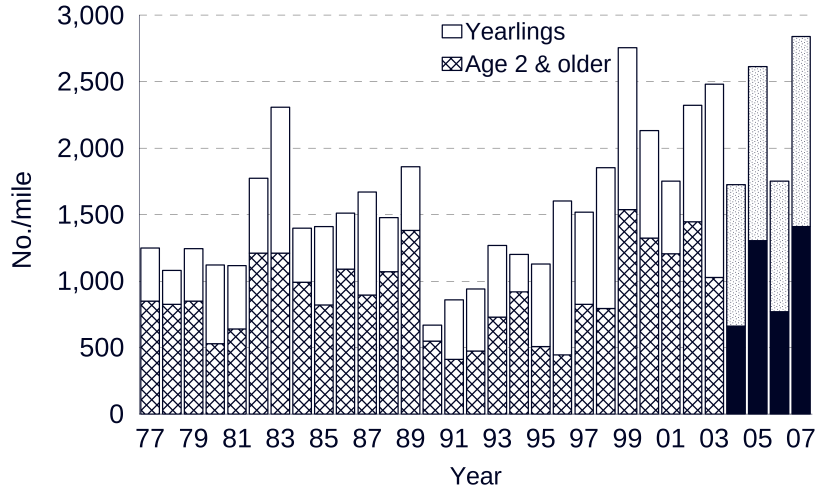


Figure B1 - 5. Brown trout populations in the Pine Butte section of the Madison River, 1977-2007, fall estimates. Estimates for 2004 - 2007 are not aged.

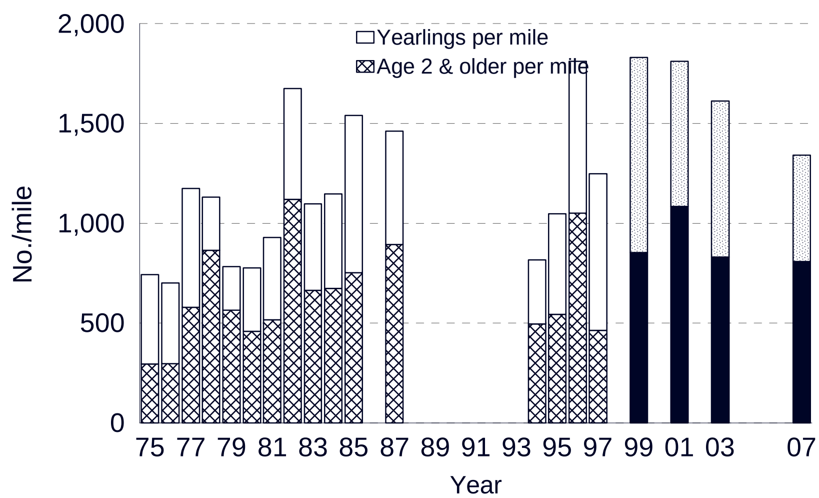


Figure B1 - 6. Brown trout populations in the Snoball section of the Madison River, 1975-2007, fall estimates. Estimates for 1999 - 2007 are not aged.

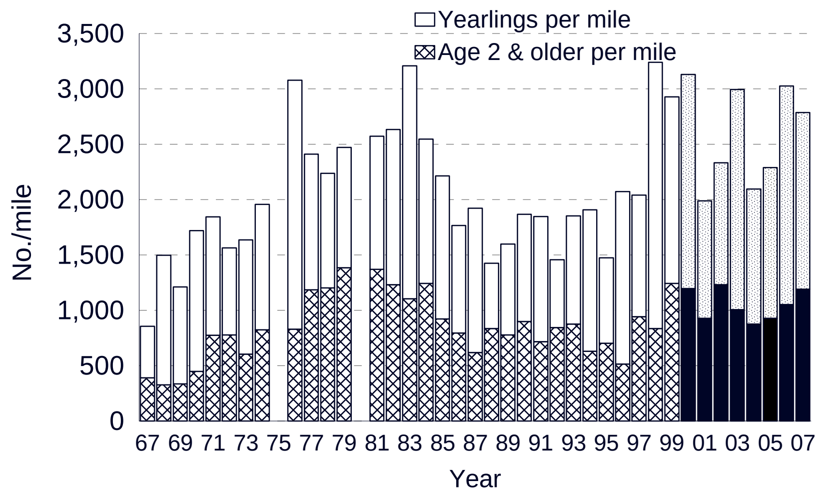


Figure B1 - 7. Brown trout populations in the Varney section of the Madison River, 1967-2007, fall estimates. Estimates for 2000 - 2007 are not aged.

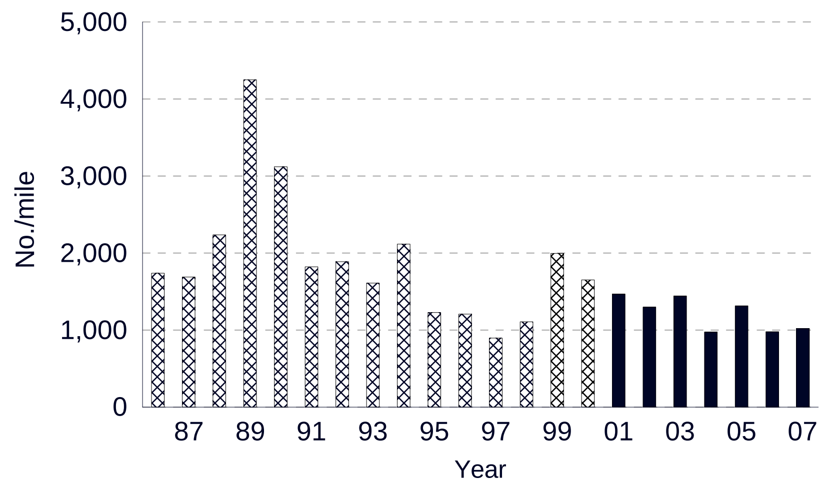


Figure B1 – 8. Brown trout populations in the Norris section of the Madison River, 1986-2007, spring estimates. Estimates for 2001 - 2007 are not aged.

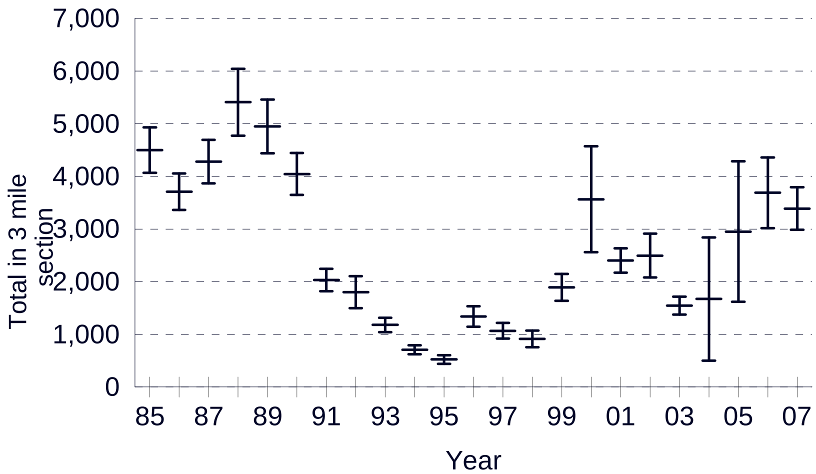
Appendix C2

Population estimates (total number in section+ 80 percent Confidence Intervals)
of age 2 & older rainbow and brown trout in the Madison River
See Figure 5 for section locations

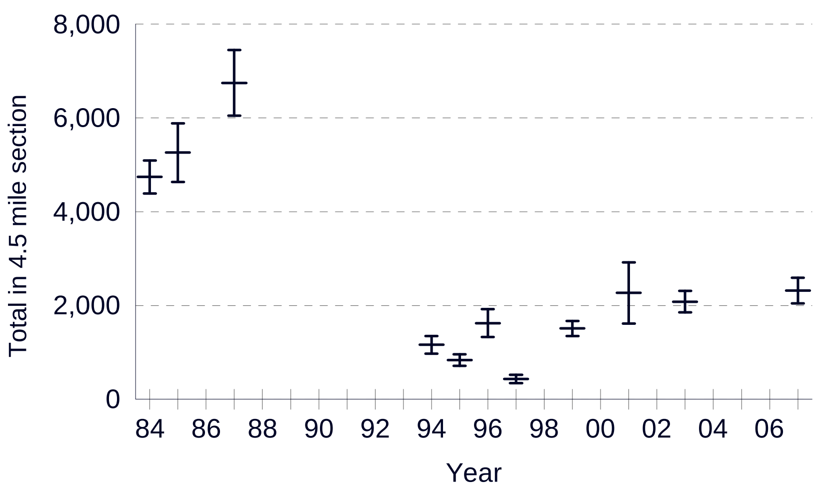
section lengths

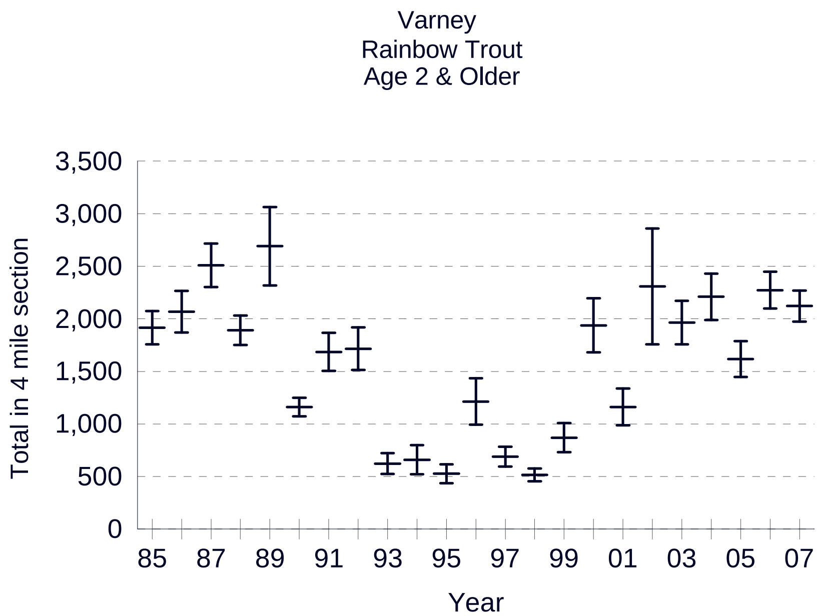
Pine Butte – 3 miles
Snoball – 4 ½ miles
Varney – 4 miles
Norris – 4 miles

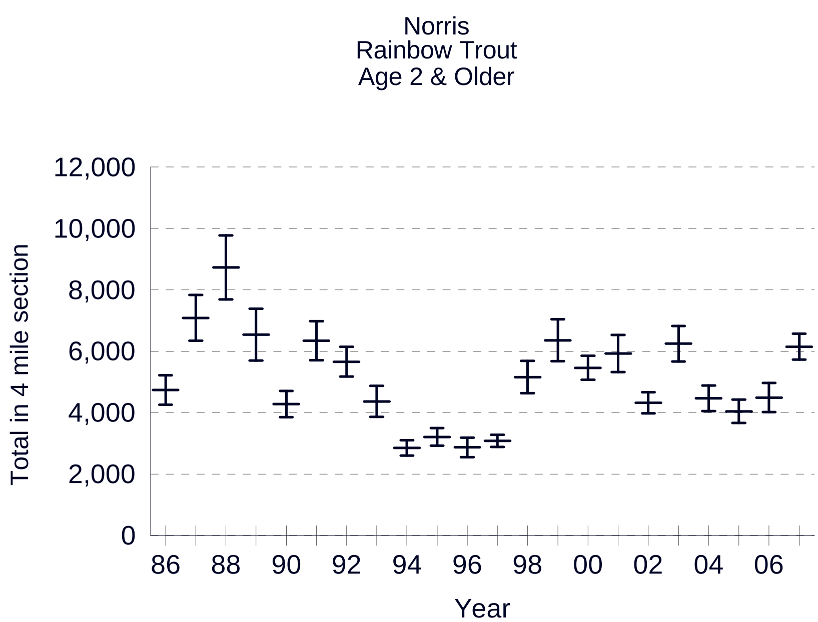
Pine Butte
Rainbow Trout
Age 2 & older

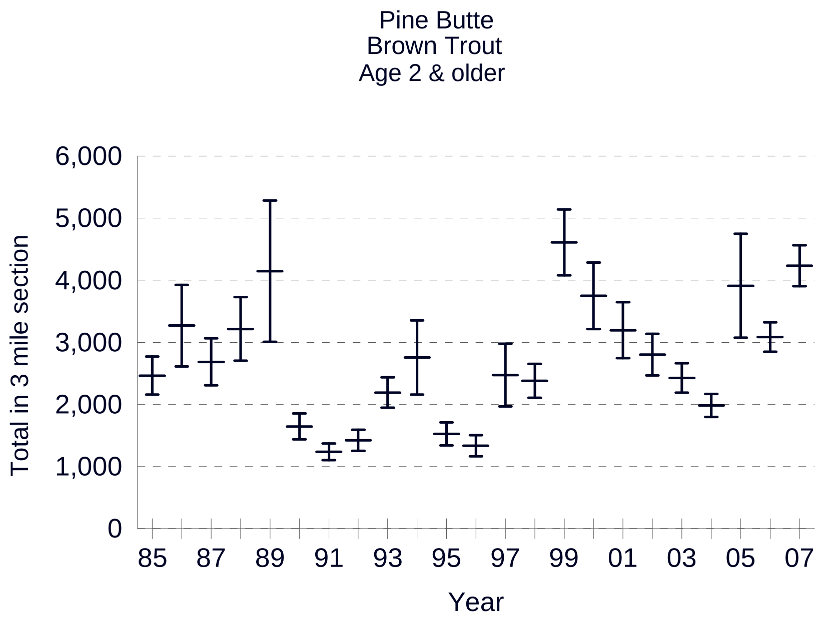


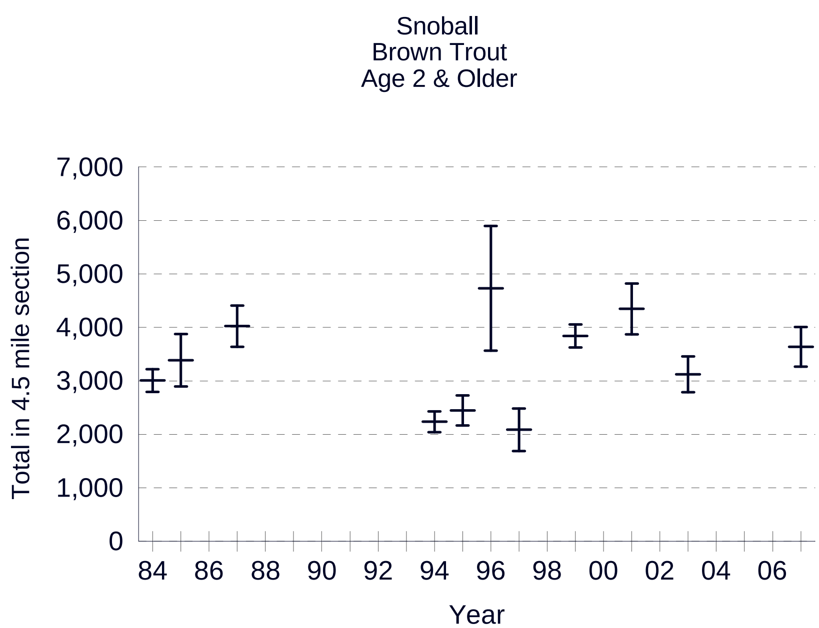
Snoball
Rainbow Trout
Age 2 & Older

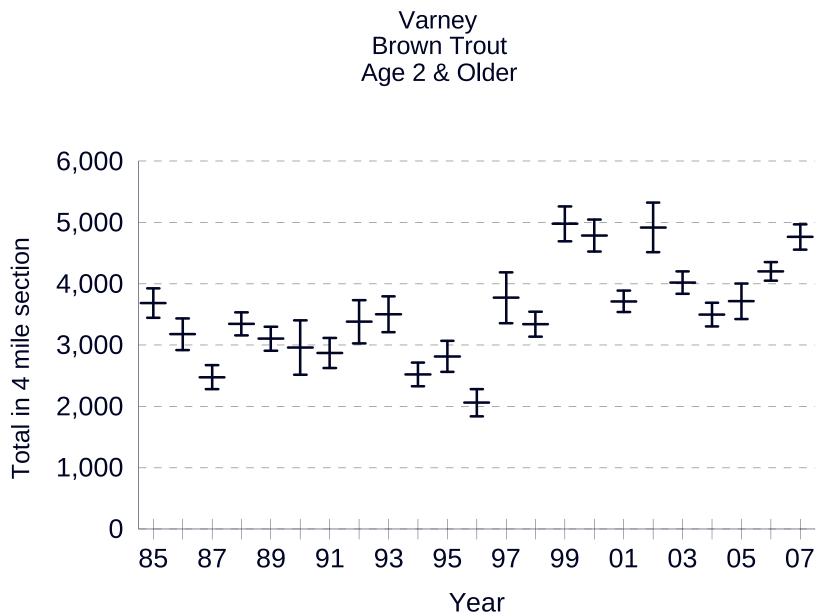


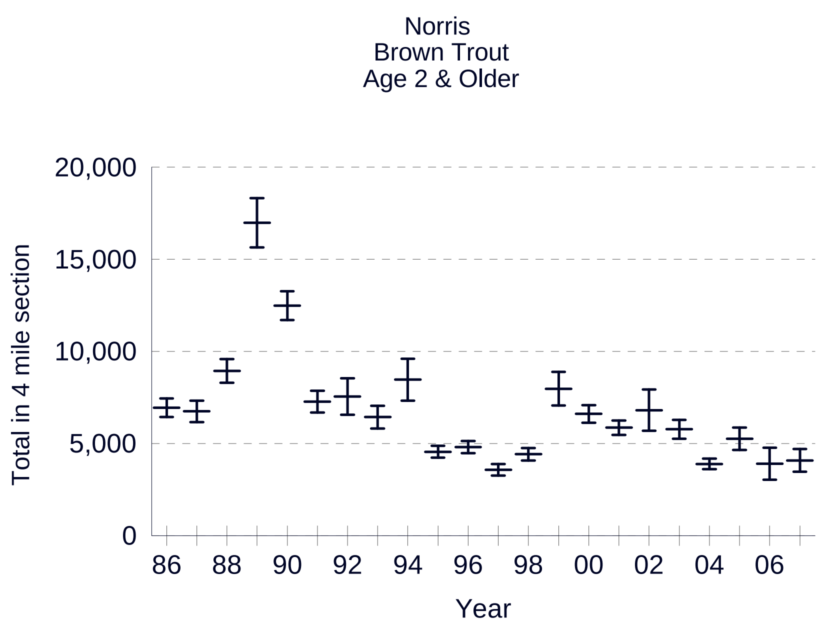

Varney
Rainbow Trout
Age 2 & Older
Total in 4 mile section
3,500
3,000
2,500
2,000
1,500
1,000
500
0
85
87
89
91
93
95
97
99
01
03
05
07
Year


Norris
Rainbow Trout
Age 2 & Older
Total in 4 mile section
12,000
10,000
8,000
6,000
4,000
2,000
0
86
88
90
92
94
96
98
00
02
04
06
Year


Pine Butte
Brown Trout
Age 2 & older
Total in 3 mile section
Year
6,000
5,000
4,000
3,000
2,000
1,000
0
85
87
89
91
93
95
97
99
01
03
05
07


Snoball
Brown Trout
Age 2 & Older
Total in 4.5 mile section
Year
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
84
86
88
90
92
94
96
98
00
02
04
06


Varney
Brown Trout
Age 2 & Older
6,000
5,000
4,000
3,000
2,000
1,000
0
Total in 4 mile section
85
87
89
91
93
95
97
99
01
03
05
07
Year

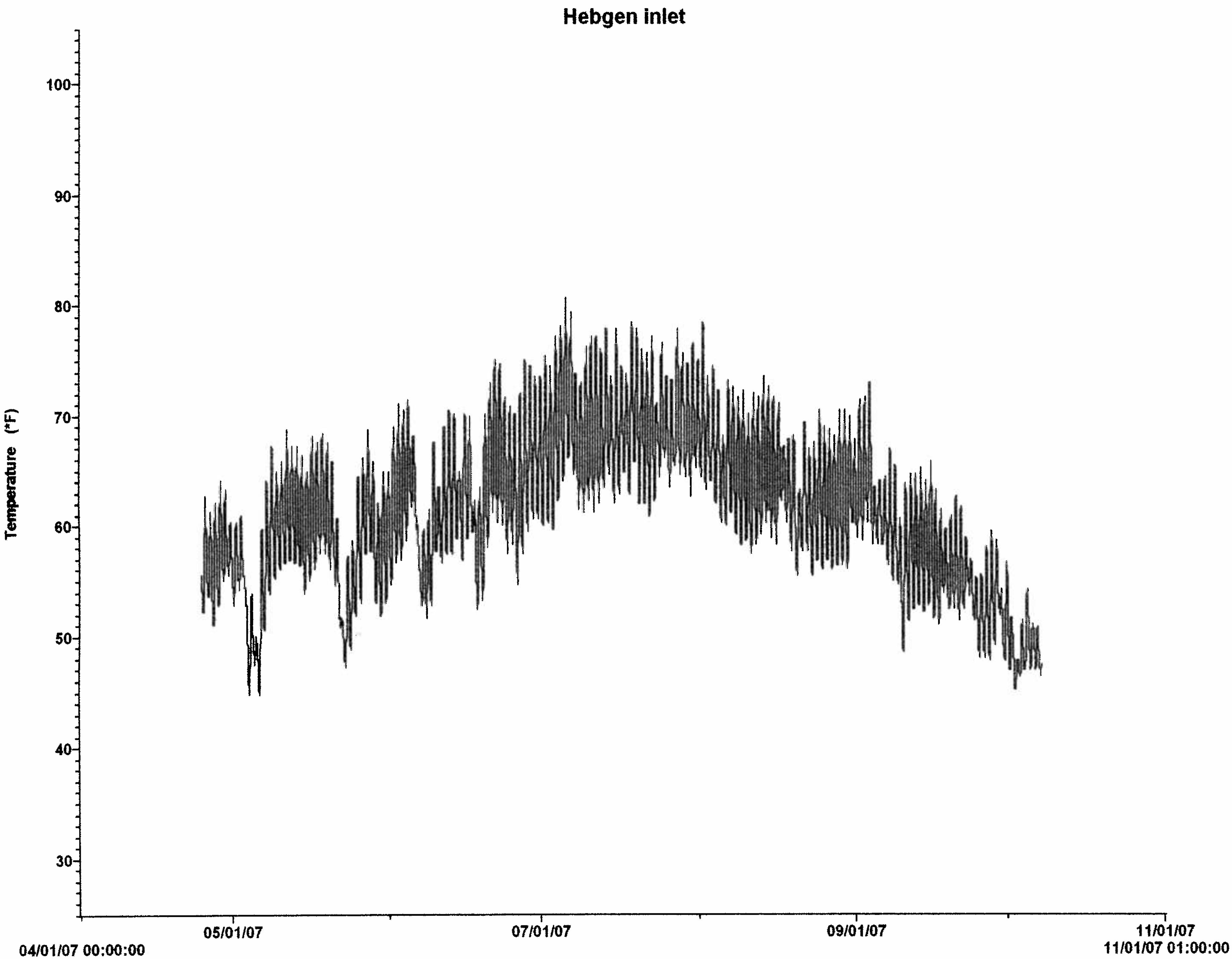

Norris
Brown Trout
Age 2 & Older
20,000
15,000
10,000
5,000
0
Total in 4 mile section
86
88
90
92
94
96
98
00
02
04
06
Year

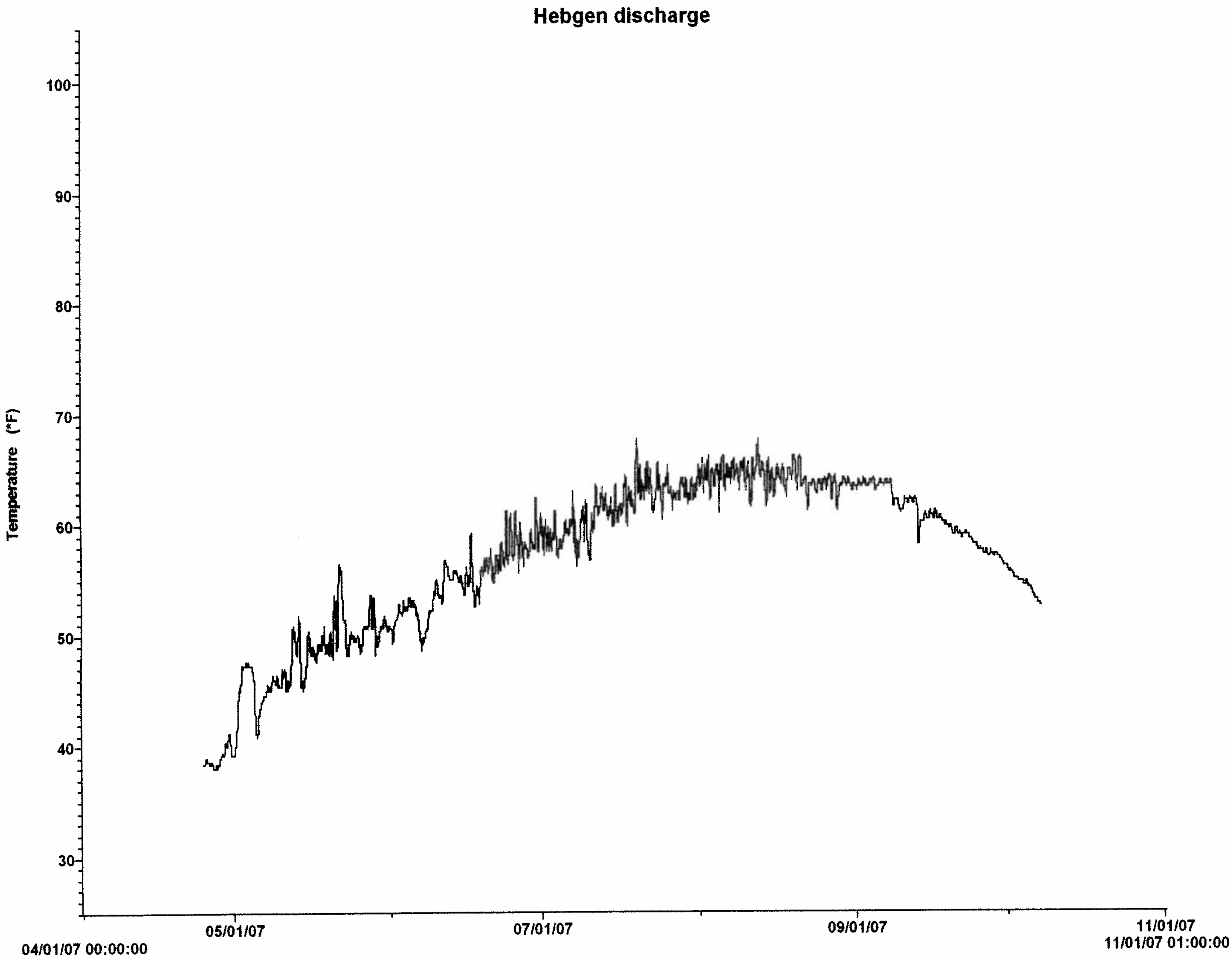
Appendix D1

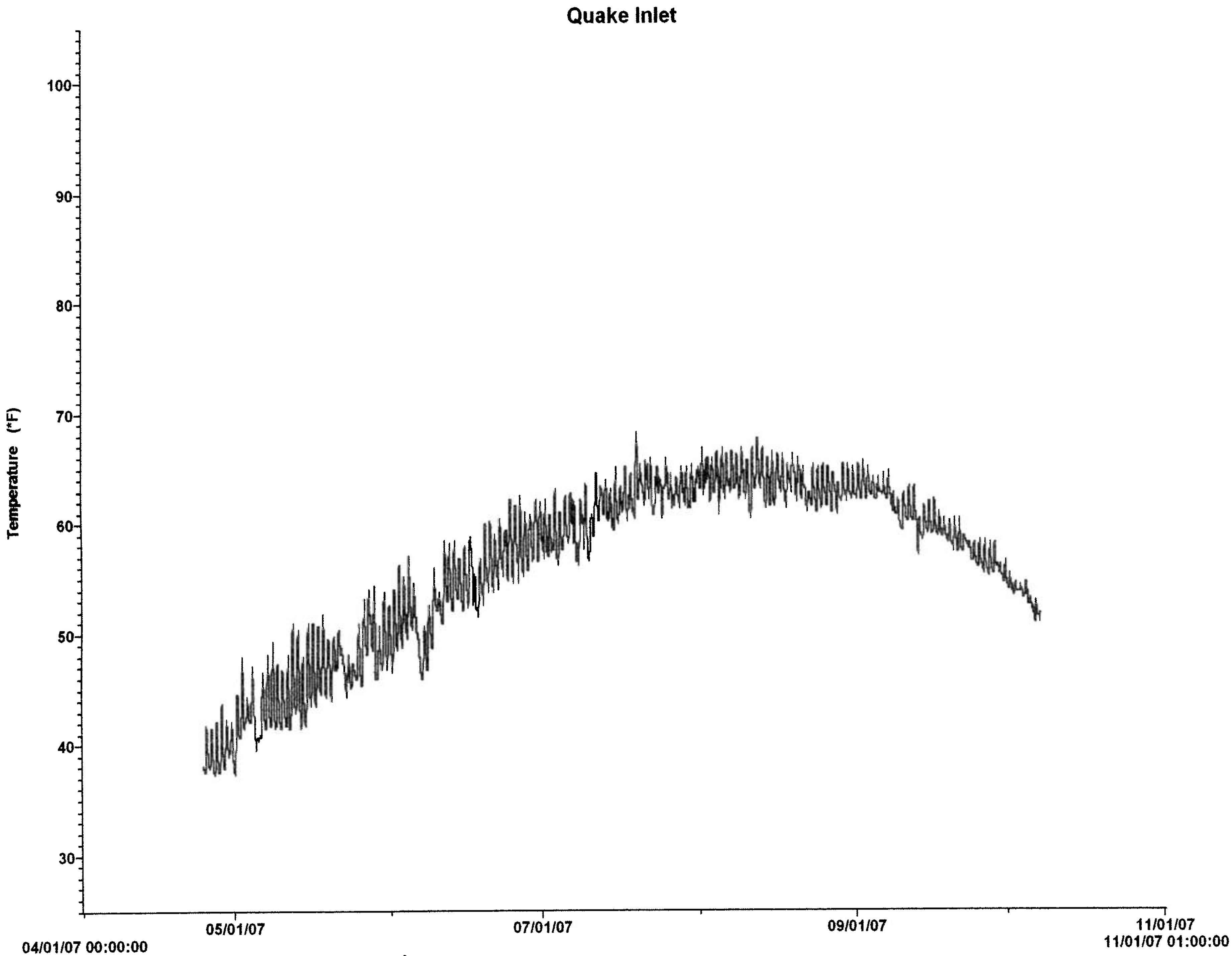
Temperature recordings from monitoring sites on the Madison River
See Figure 5 for locations

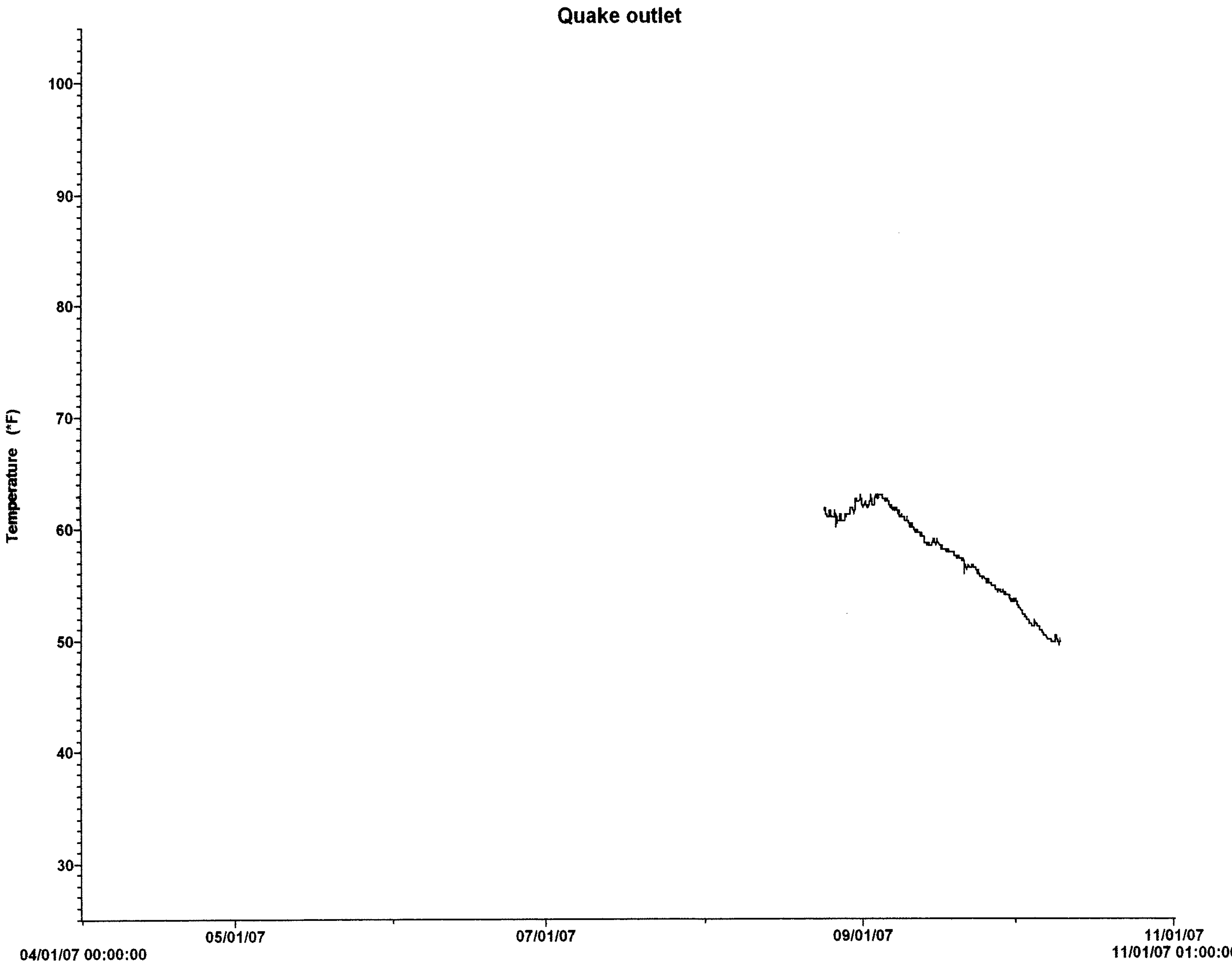
NOTES:

- Quake Lake outlet recorder ceased functioning and was replaced on August 24. Data could not be recovered from the original recorder.

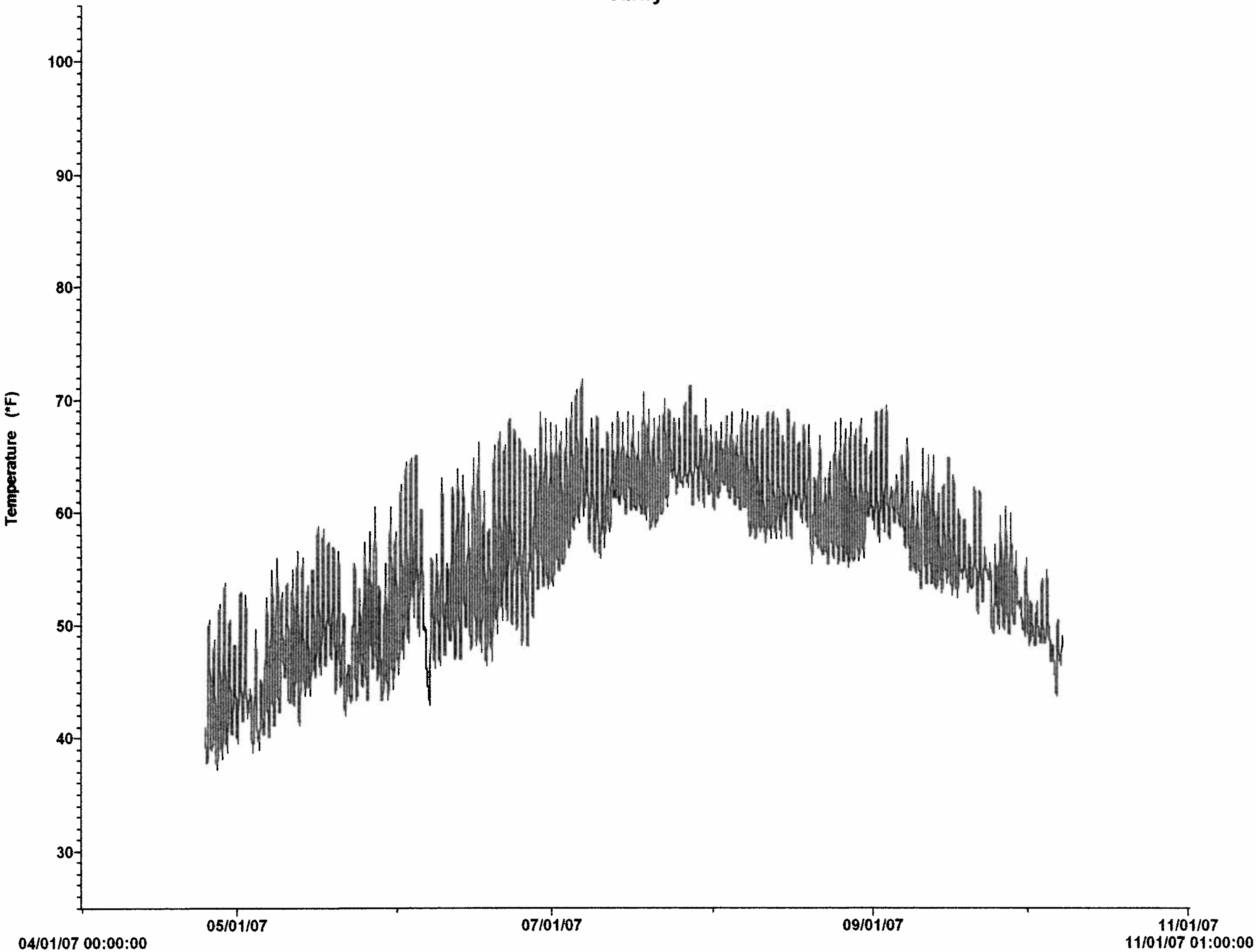

Hebgen inlet
Temperature (°F)
100
90
80
70
60
50
40
30
04/01/07 00:00:00
05/01/07
07/01/07
09/01/07
11/01/07
11/01/07 01:00:00


Hebgen discharge
Temperature (*F)
100
90
80
70
60
50
40
30
04/01/07 00:00:00
05/01/07
07/01/07
09/01/07
11/01/07
11/01/07 01:00:00

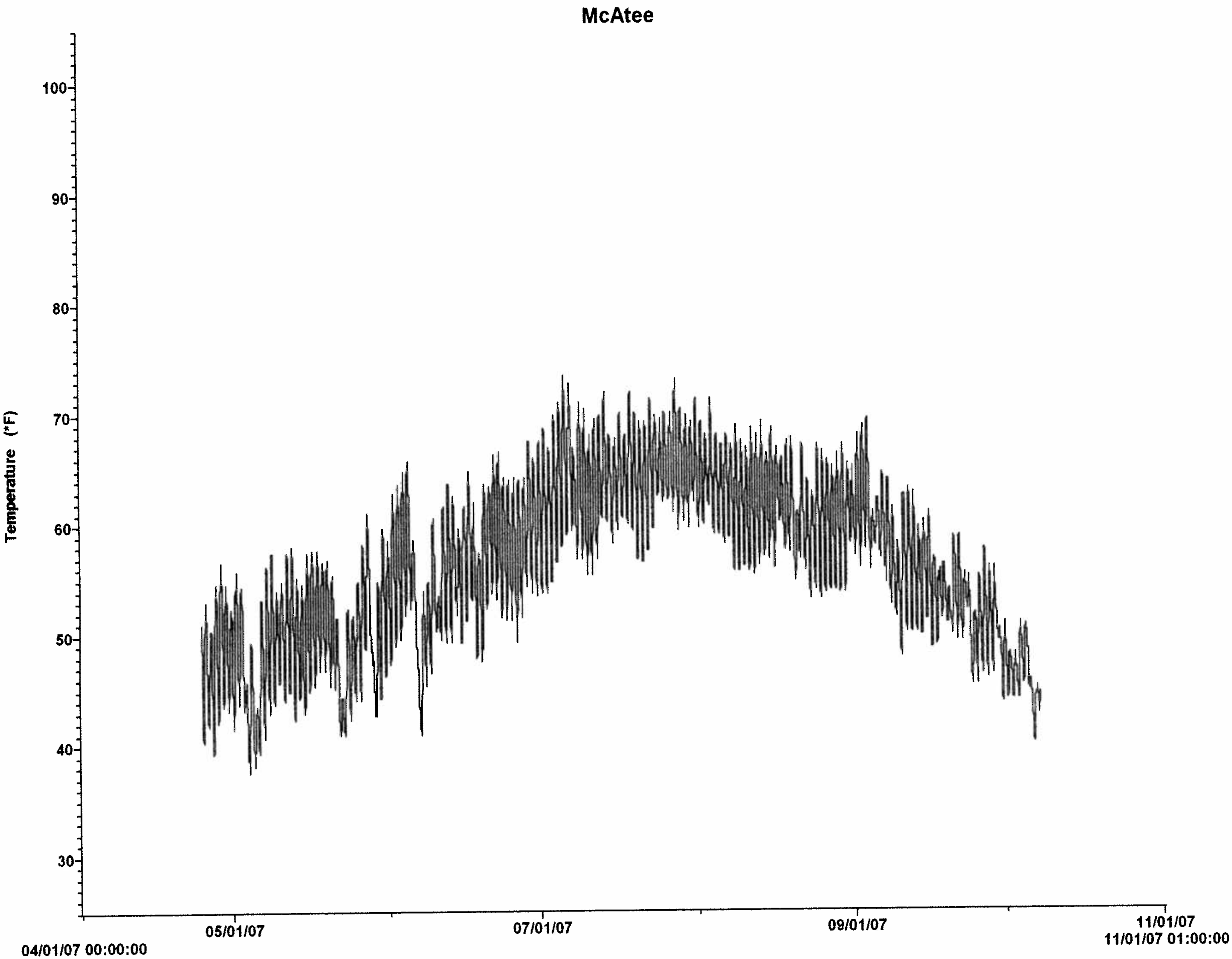

Quake Inlet
Temperature (*F)
100
90
80
70
60
50
40
30
04/01/07 00:00:00
05/01/07
07/01/07
09/01/07
11/01/07
11/01/07 01:00:00


Quake outlet
Temperature (*F)
100
90
80
70
60
50
40
30
04/01/07 00:00:00
05/01/07
07/01/07
09/01/07
11/01/07
11/01/07 01:00:00

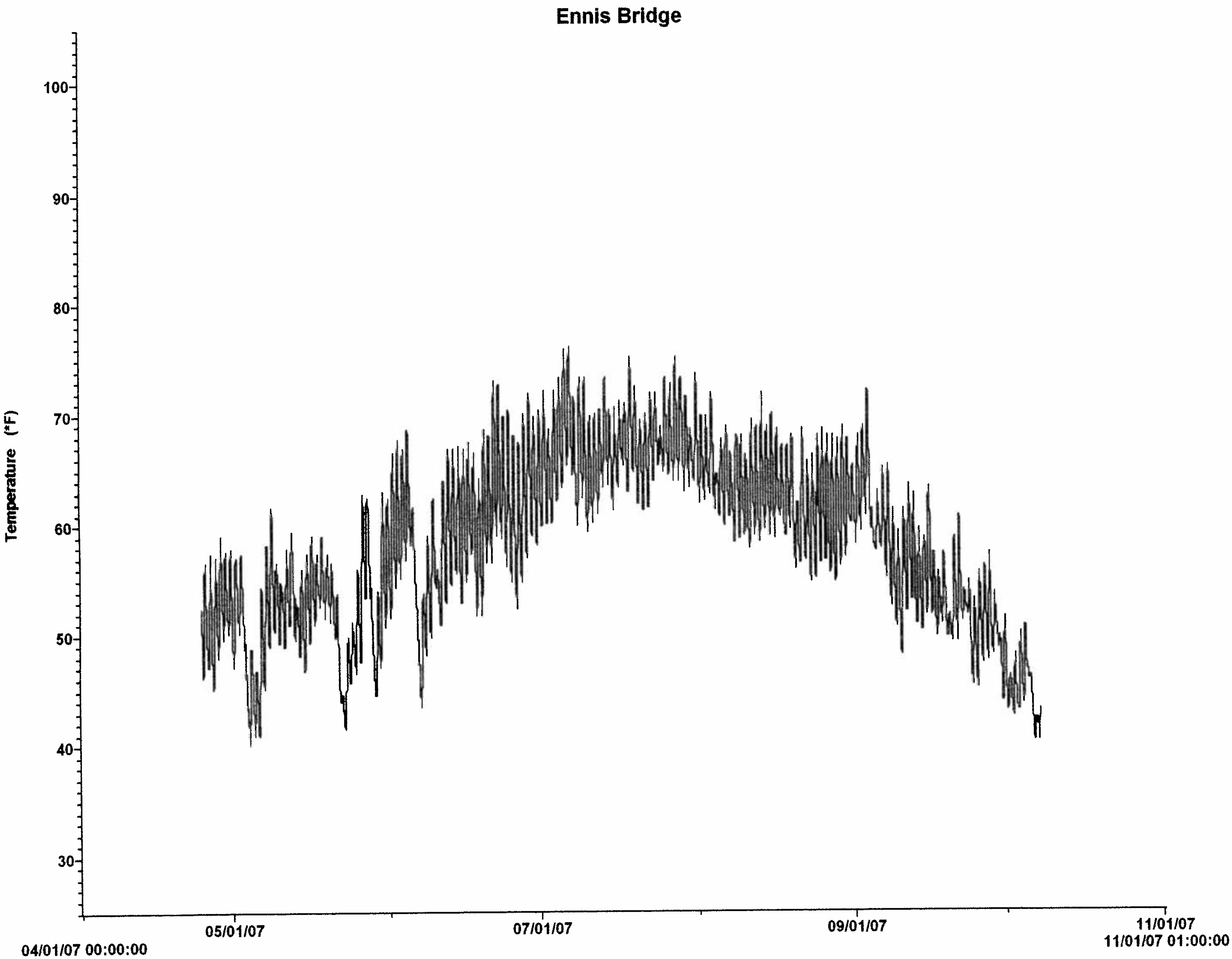
Kirby



Temperature (°F)
100
90
80
70
60
50
40
30
04/01/07 00:00:00
05/01/07
07/01/07
09/01/07
11/01/07
11/01/07 01:00:00

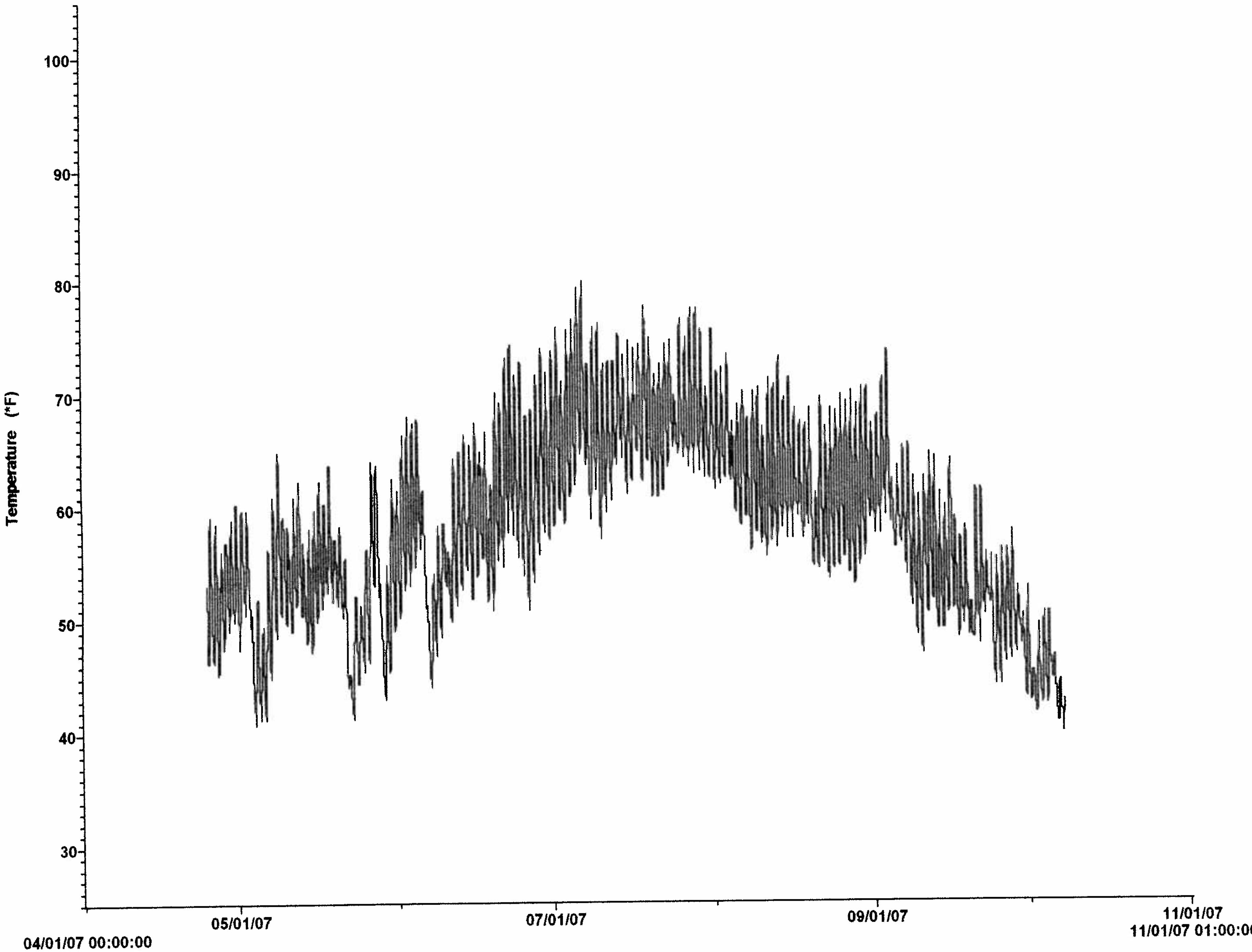


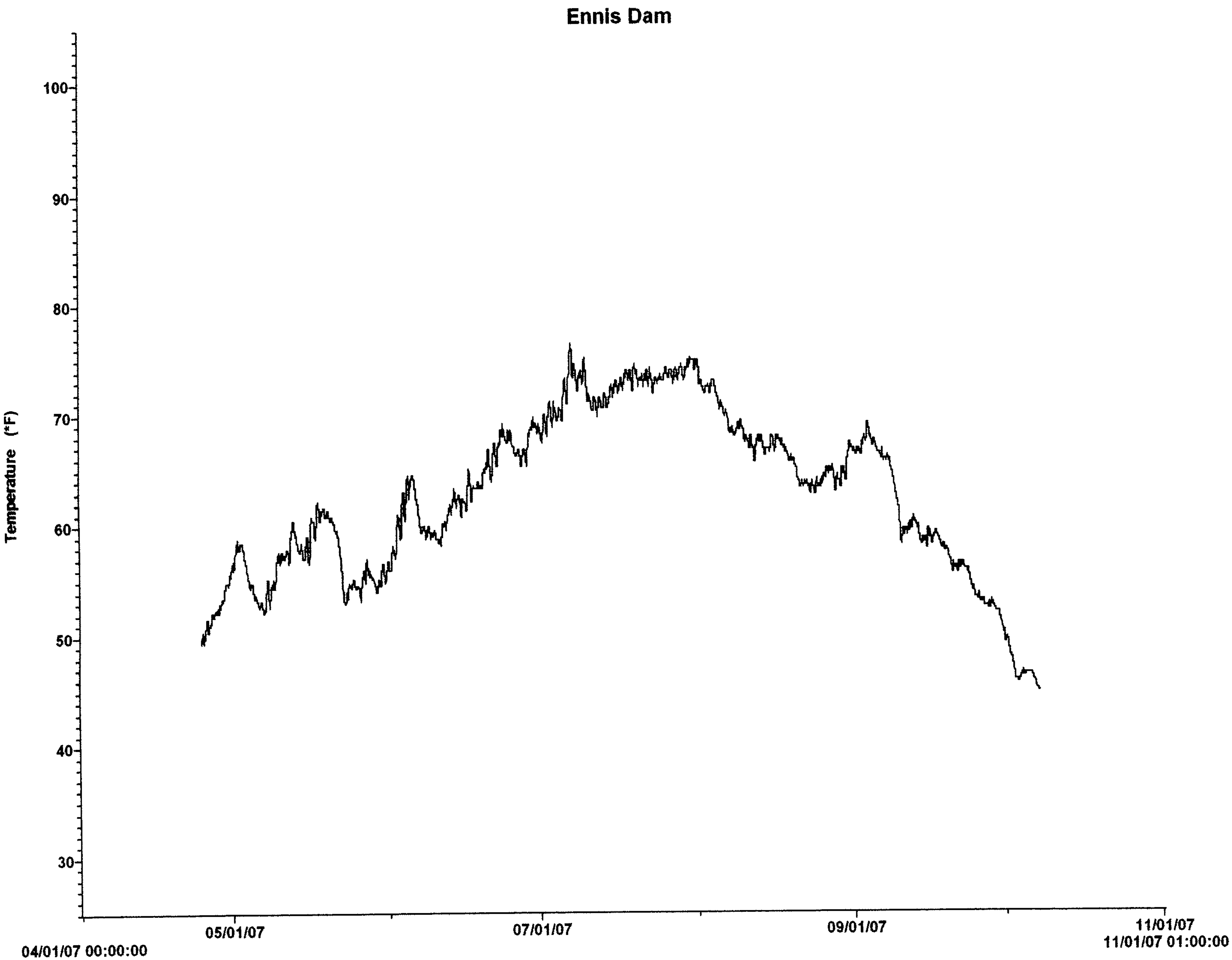
McAtee
Temperature (*F)
100
90
80
70
60
50
40
30
05/01/07
07/01/07
09/01/07
11/01/07
04/01/07 00:00:00
11/01/07 01:00:00

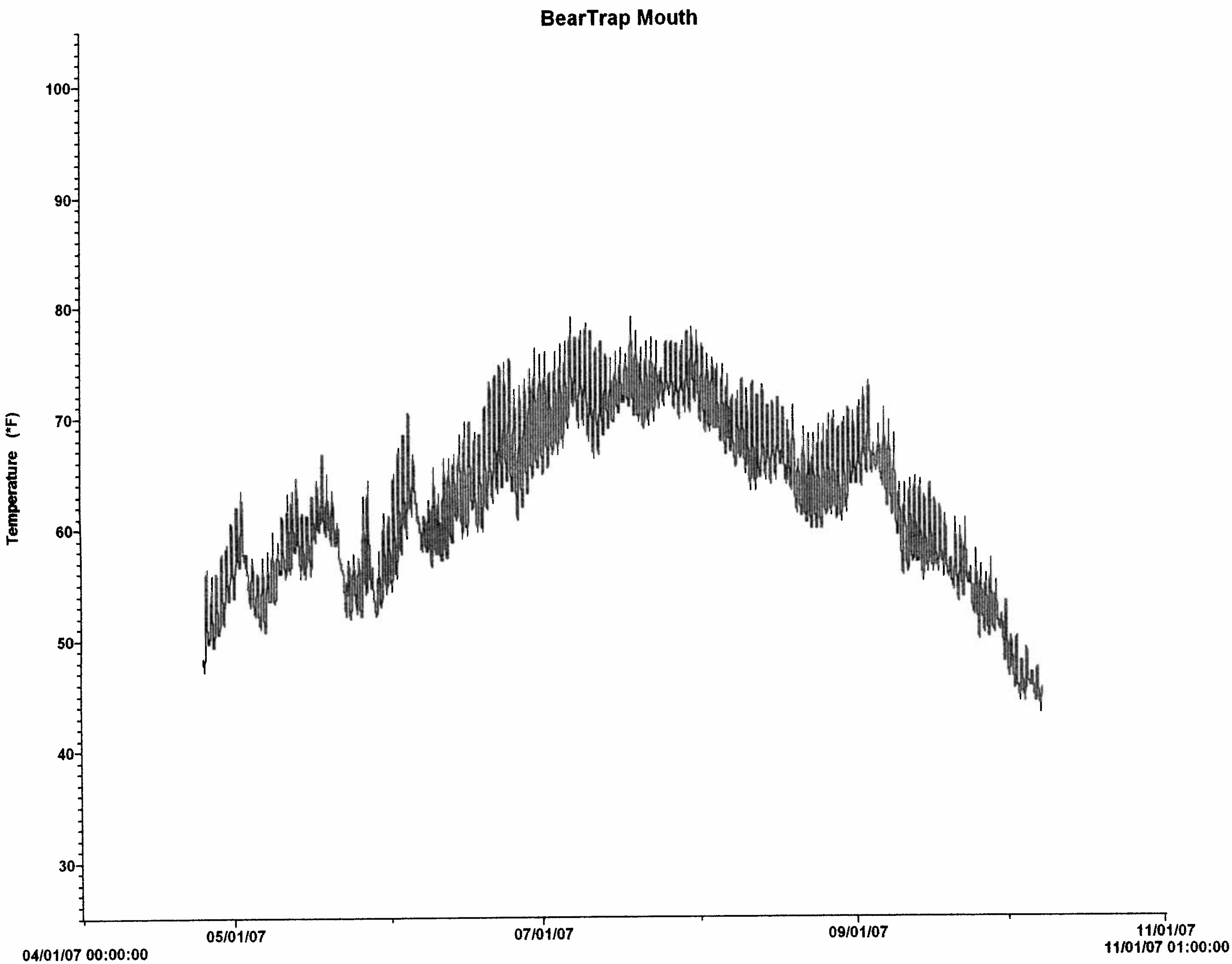


Ennis Bridge
Temperature (*F)
100
90
80
70
60
50
40
30
04/01/07 00:00:00
05/01/07
07/01/07
09/01/07
11/01/07
11/01/07 01:00:00

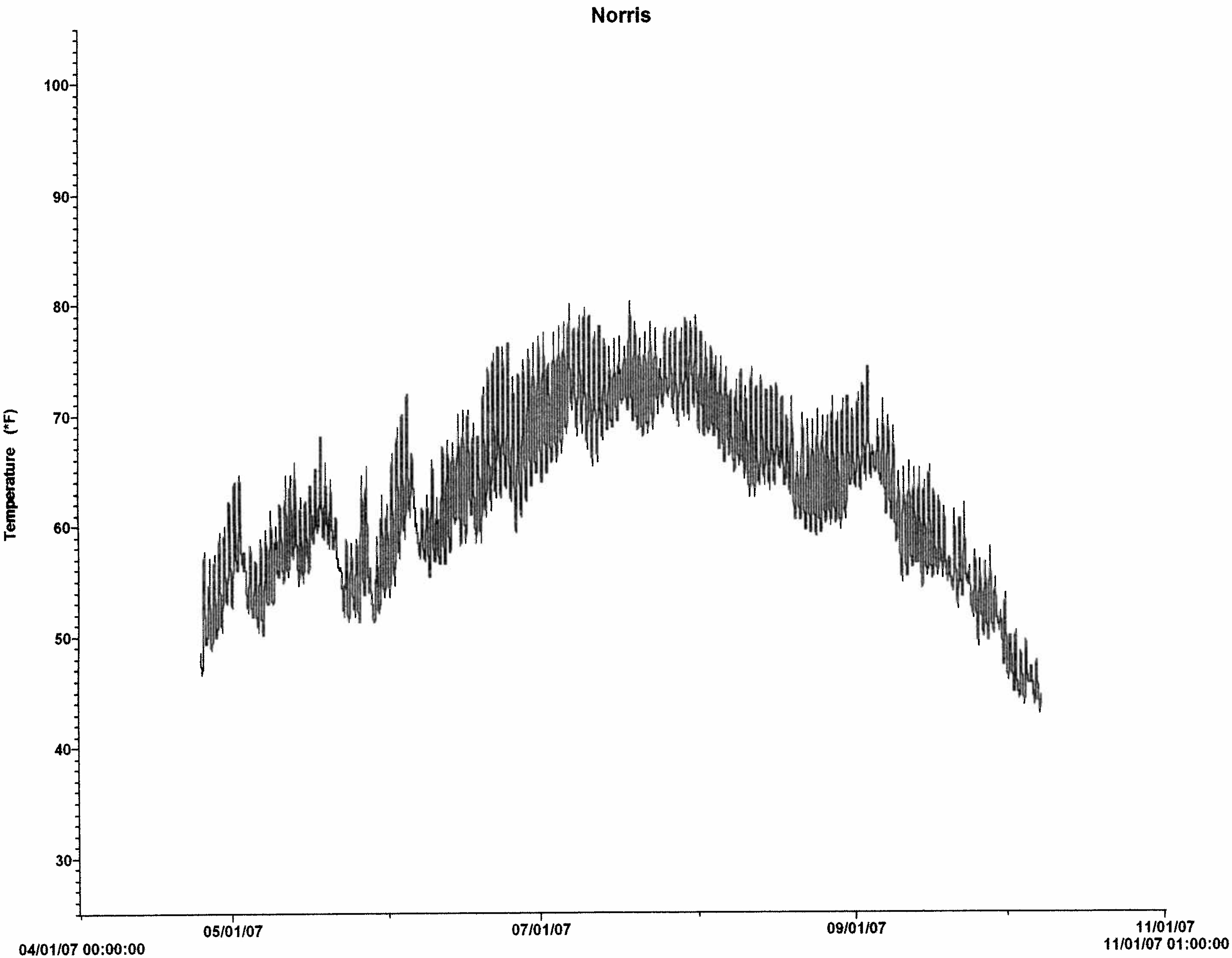
Ennis Reservoir Inlet



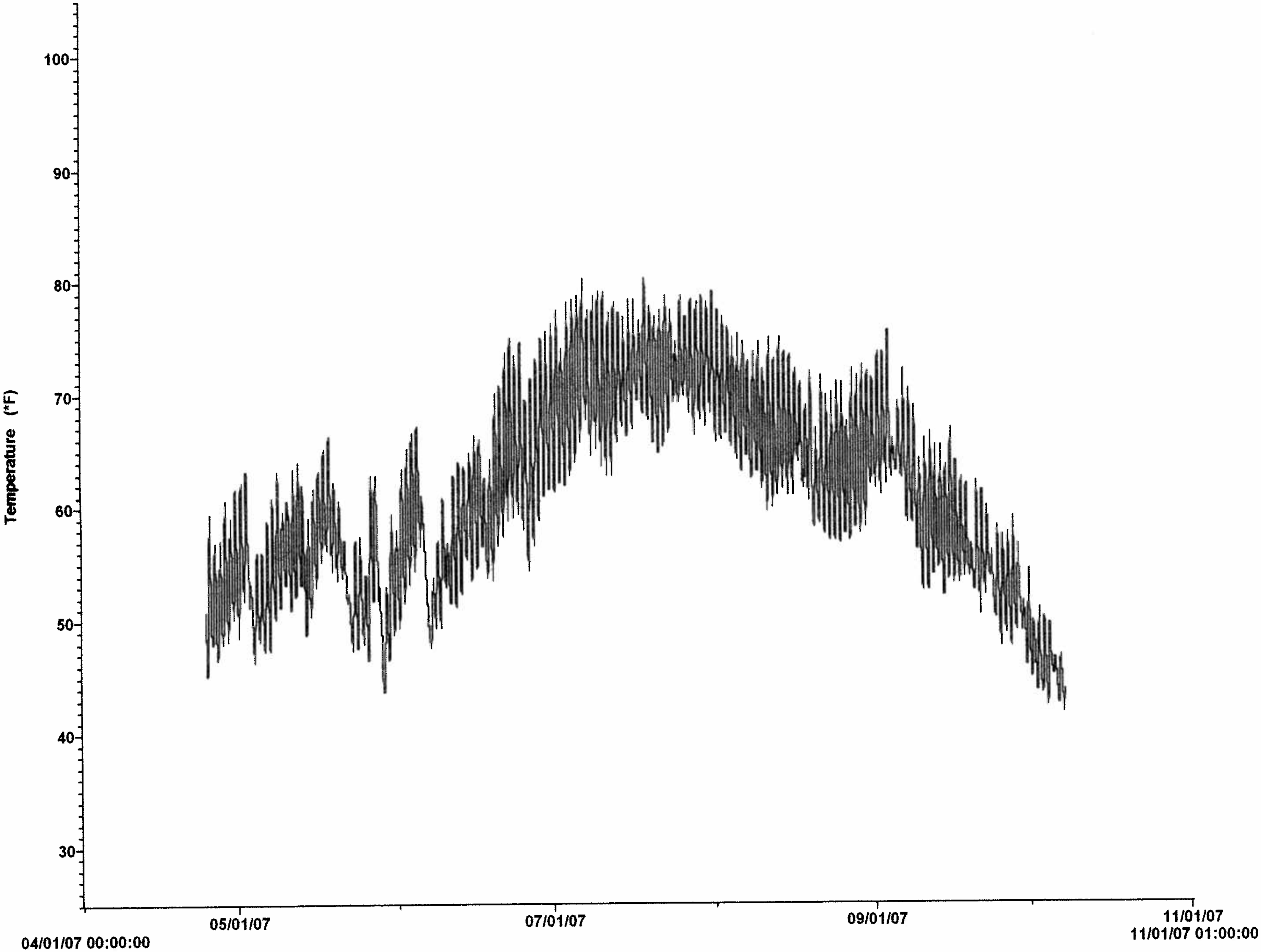

Ennis Dam
Temperature (*F)
100
90
80
70
60
50
40
30
04/01/07 00:00:00
05/01/07
07/01/07
09/01/07
11/01/07
11/01/07 01:00:00



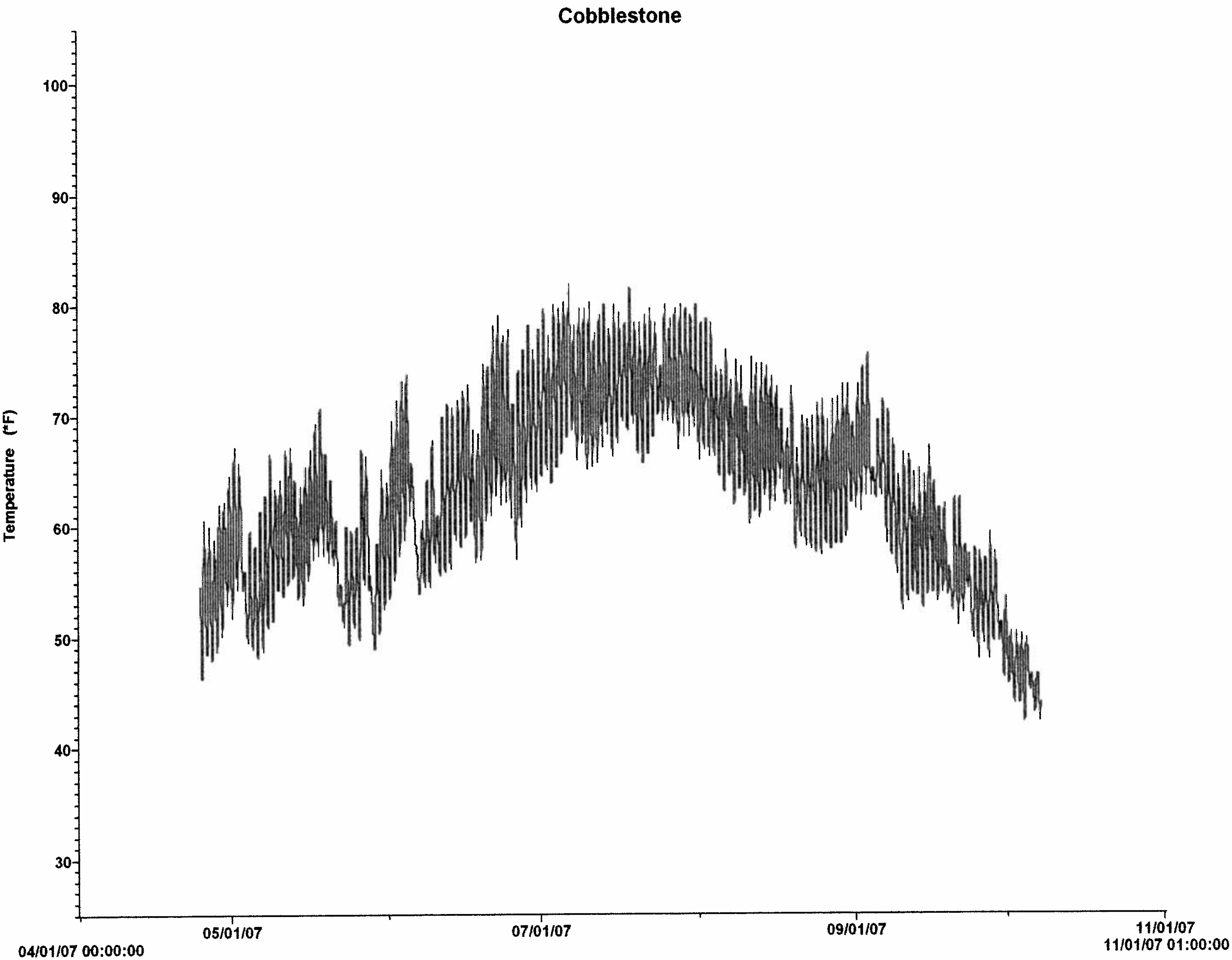
BearTrap Mouth
Temperature (*F)
100
90
80
70
60
50
40
30
04/01/07 00:00:00
05/01/07
07/01/07
09/01/07
11/01/07
11/01/07 01:00:00


Norris
Temperature (°F)
100
90
80
70
60
50
40
30
04/01/07 00:00:00
05/01/07
07/01/07
09/01/07
11/01/07
11/01/07 01:00:00

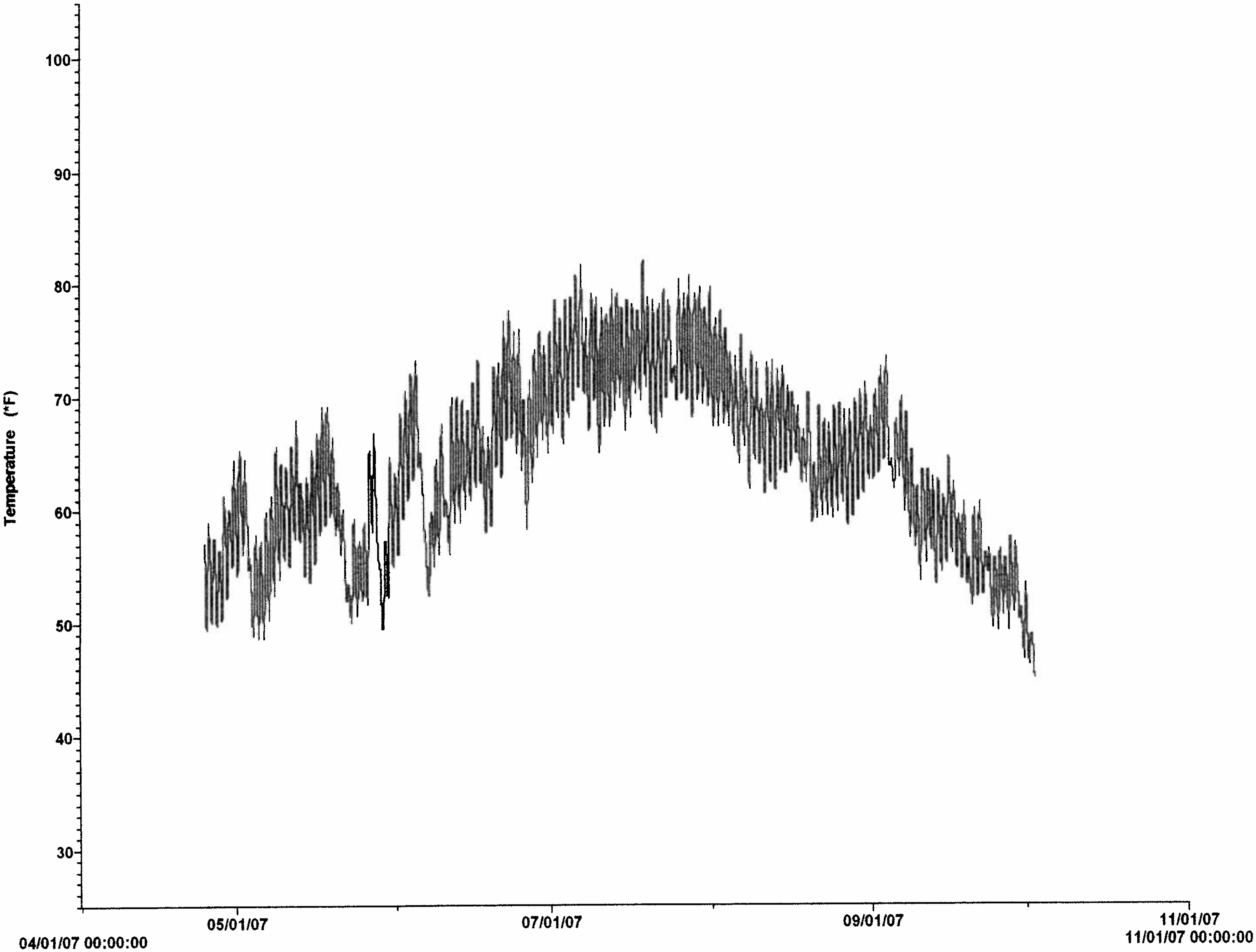
Black's Ford

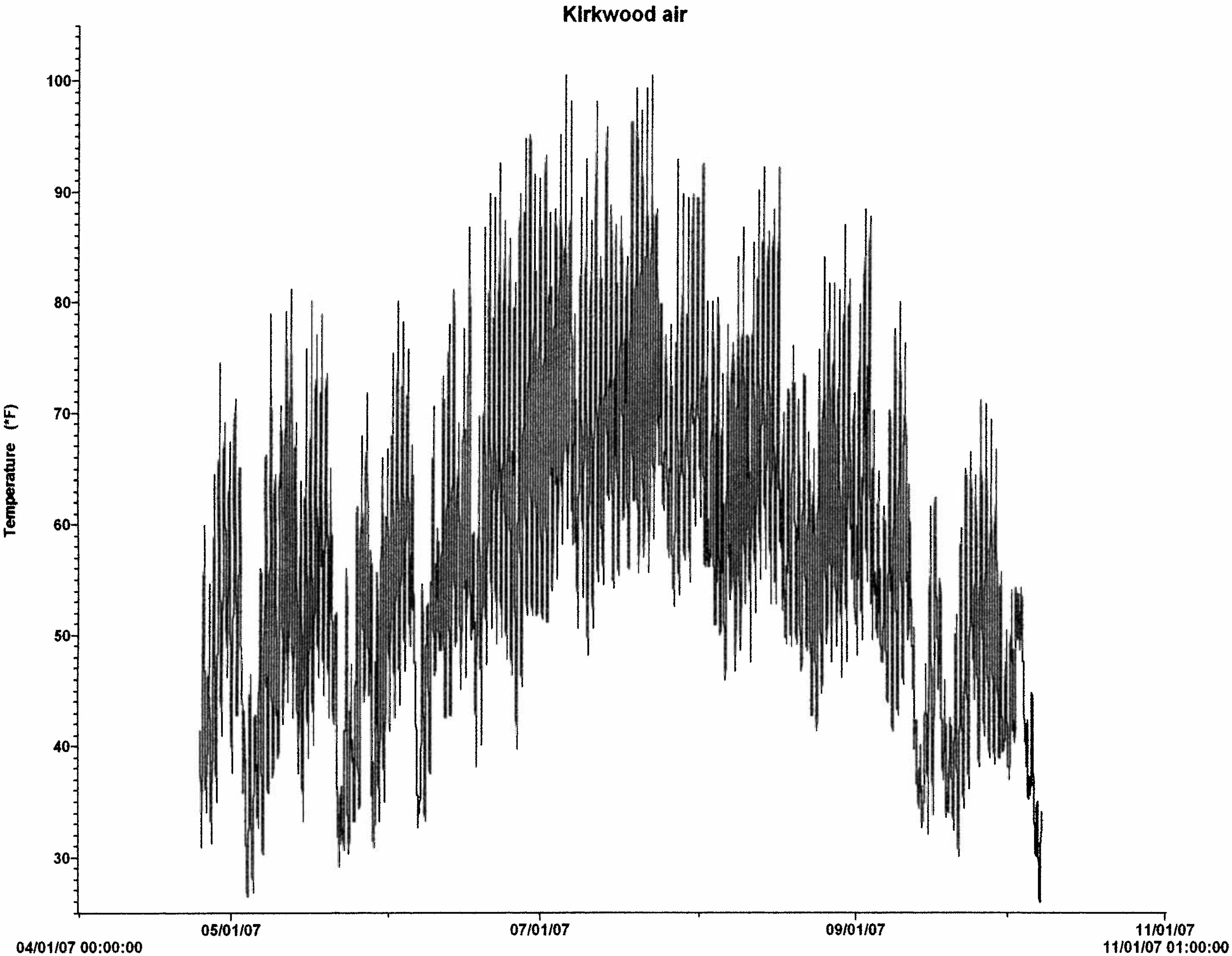


100
90
80
70
60
50
40
30
Temperature (*F)
05/01/07
07/01/07
09/01/07
11/01/07
04/01/07 00:00:00
11/01/07 01:00:00

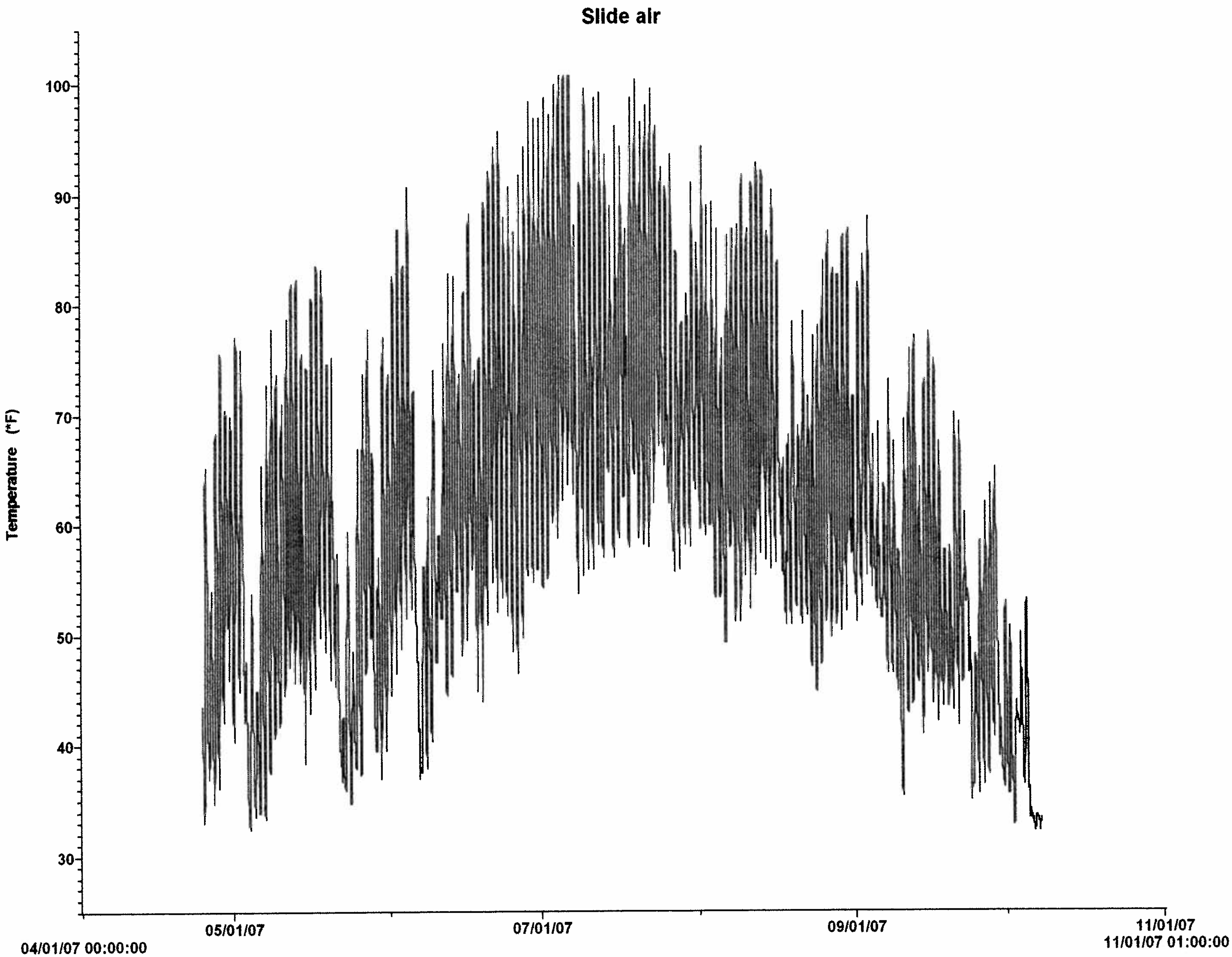

Cobblestone
Temperature (°F)
100
90
80
70
60
50
40
30
04/01/07 00:00:00
05/01/07
07/01/07
09/01/07
11/01/07
11/01/07 01:00:00

Headwaters State Park



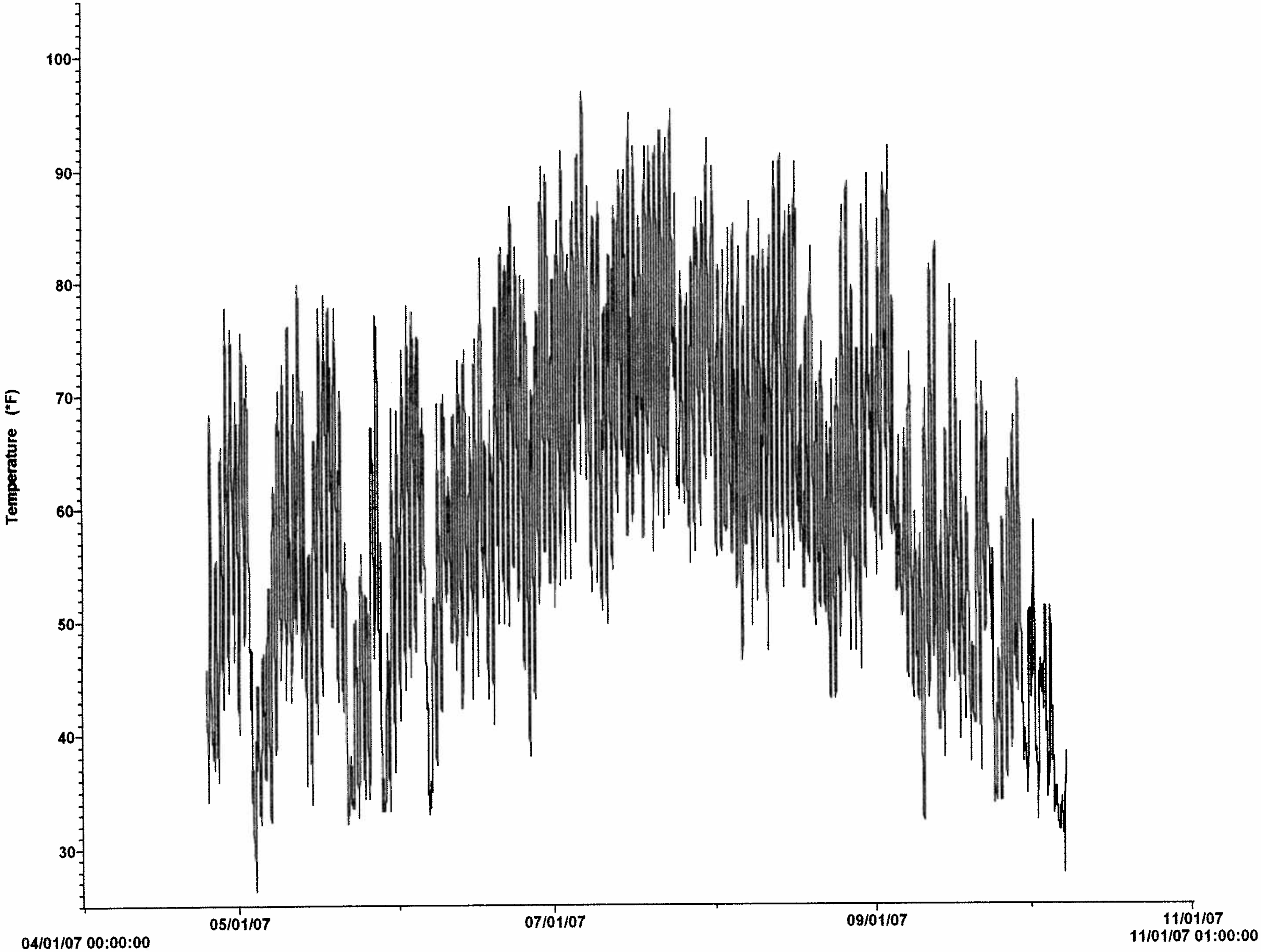


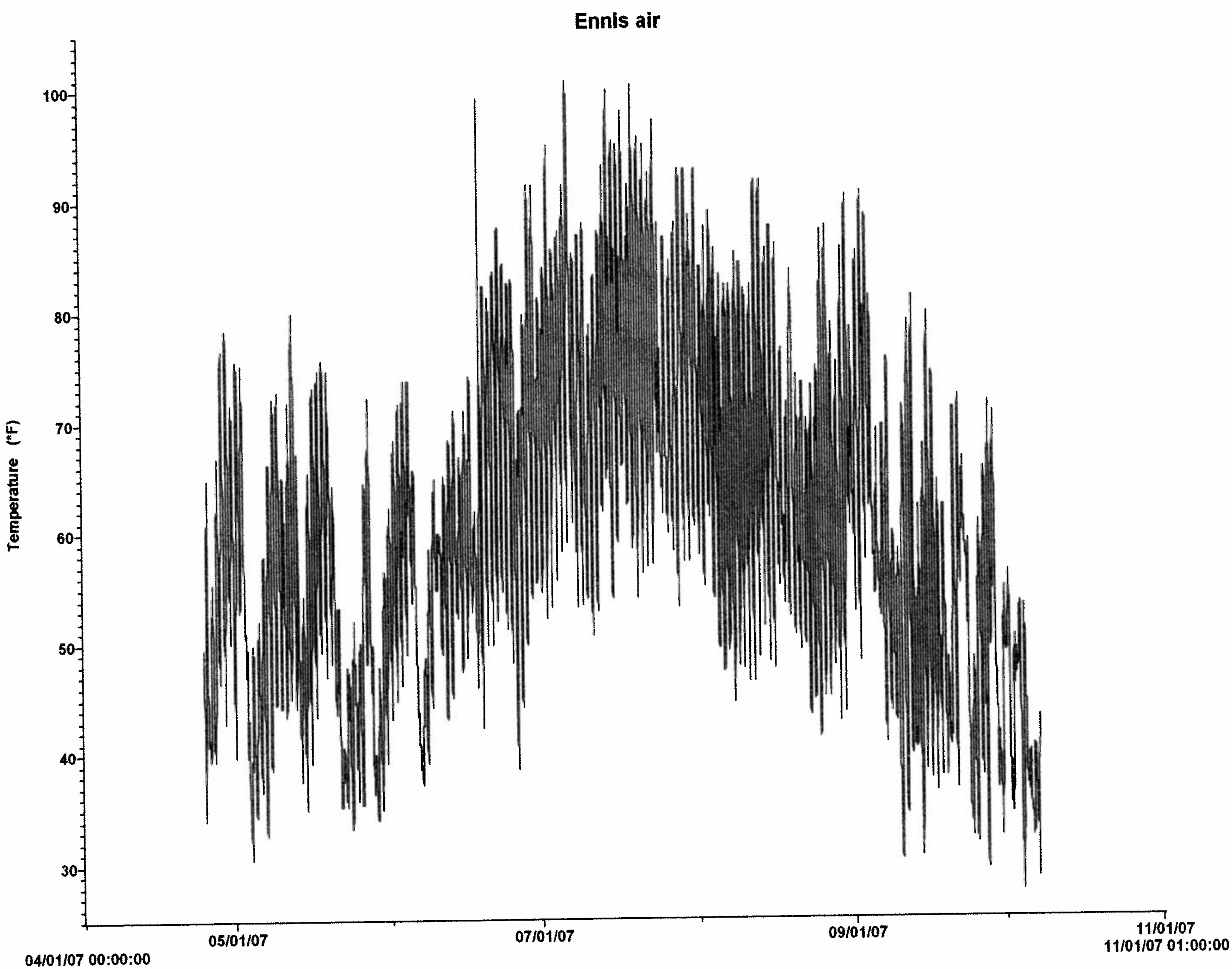
Kirkwood air
Temperature (*F)
100
90
80
70
60
50
40
30
04/01/07 00:00:00
05/01/07
07/01/07
09/01/07
11/01/07
11/01/07 01:00:00

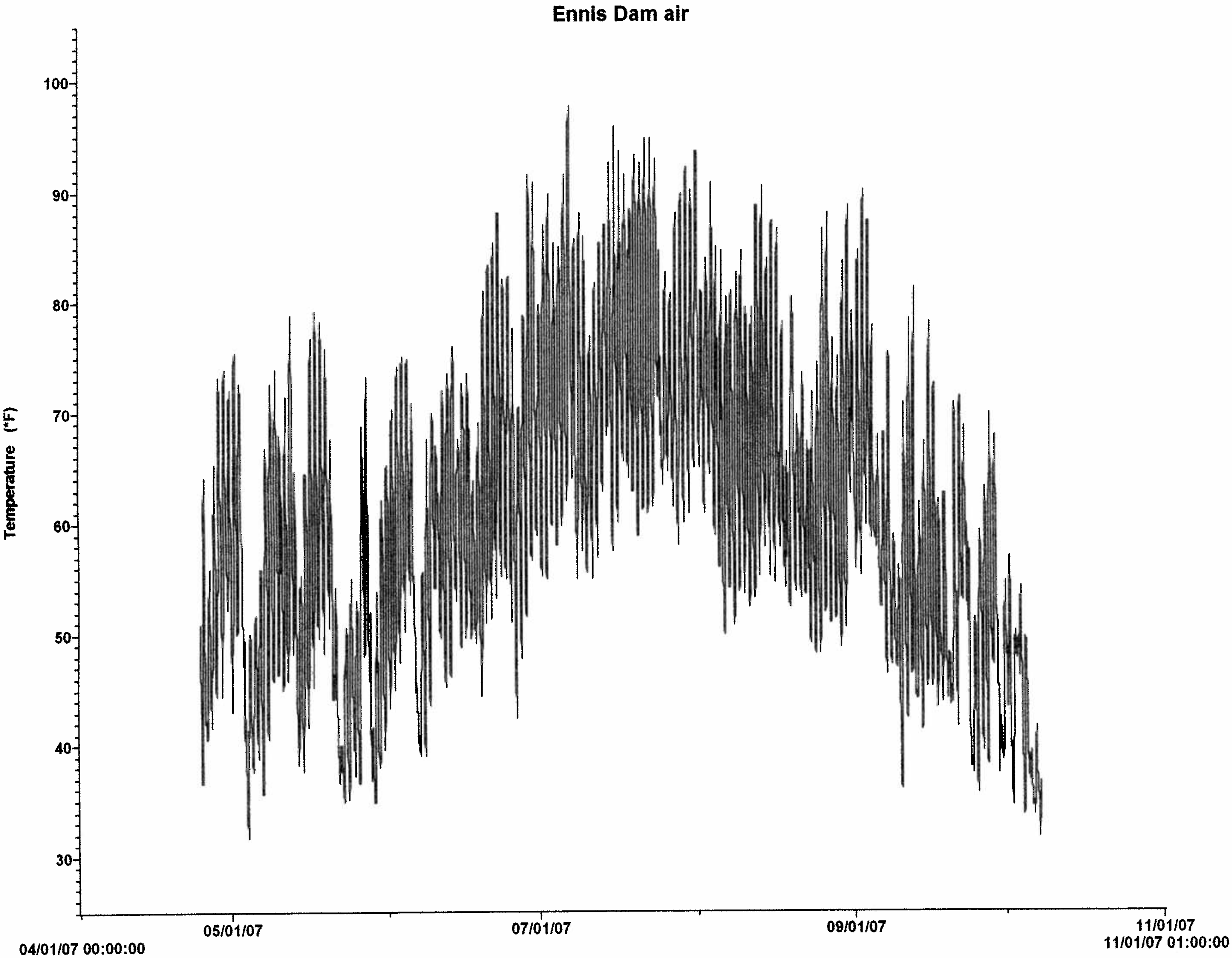


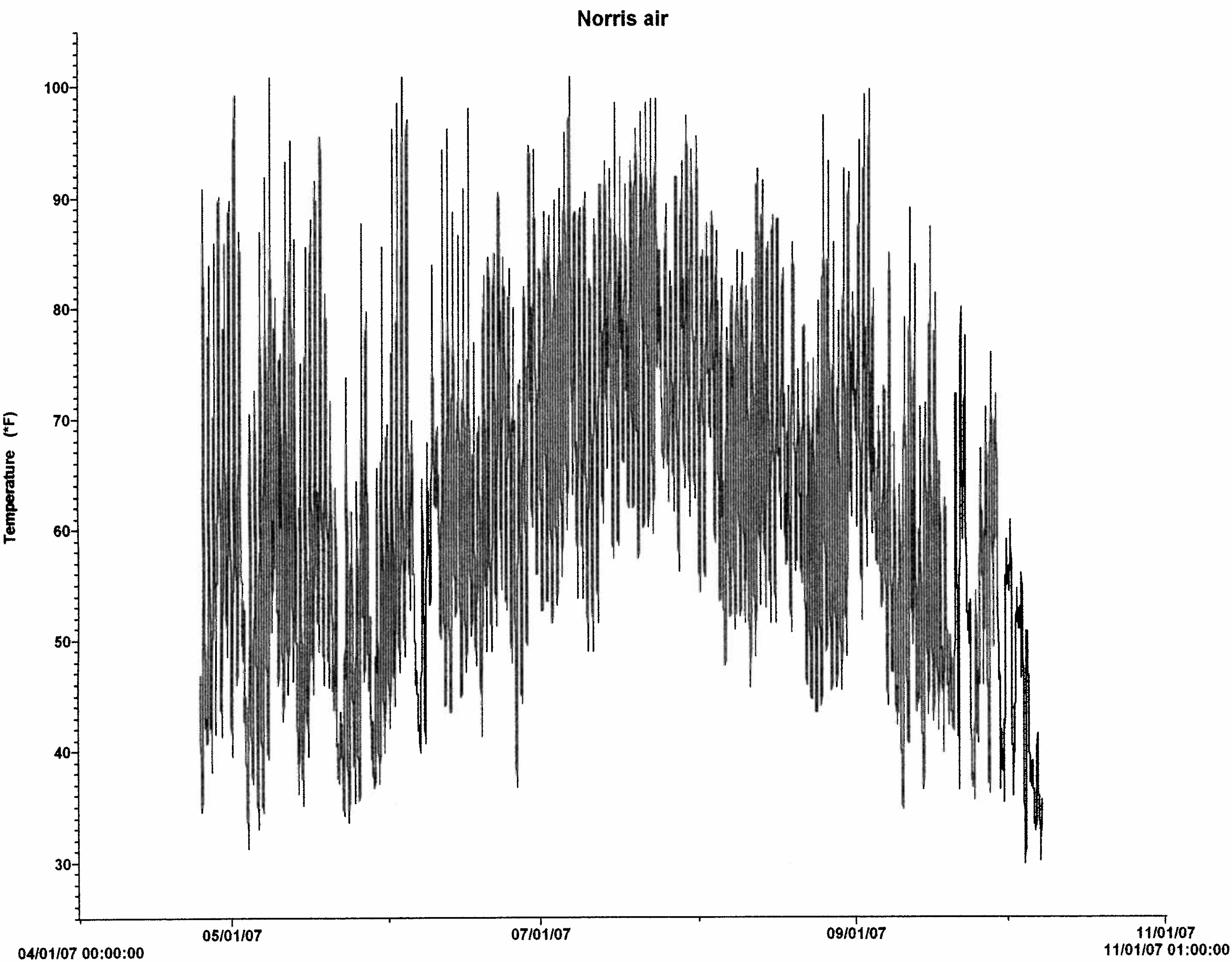
Slide air
Temperature (*F)
100
90
80
70
60
50
40
30
05/01/07
07/01/07
09/01/07
11/01/07
04/01/07 00:00:00
11/01/07 01:00:00

Wall Creek HQ

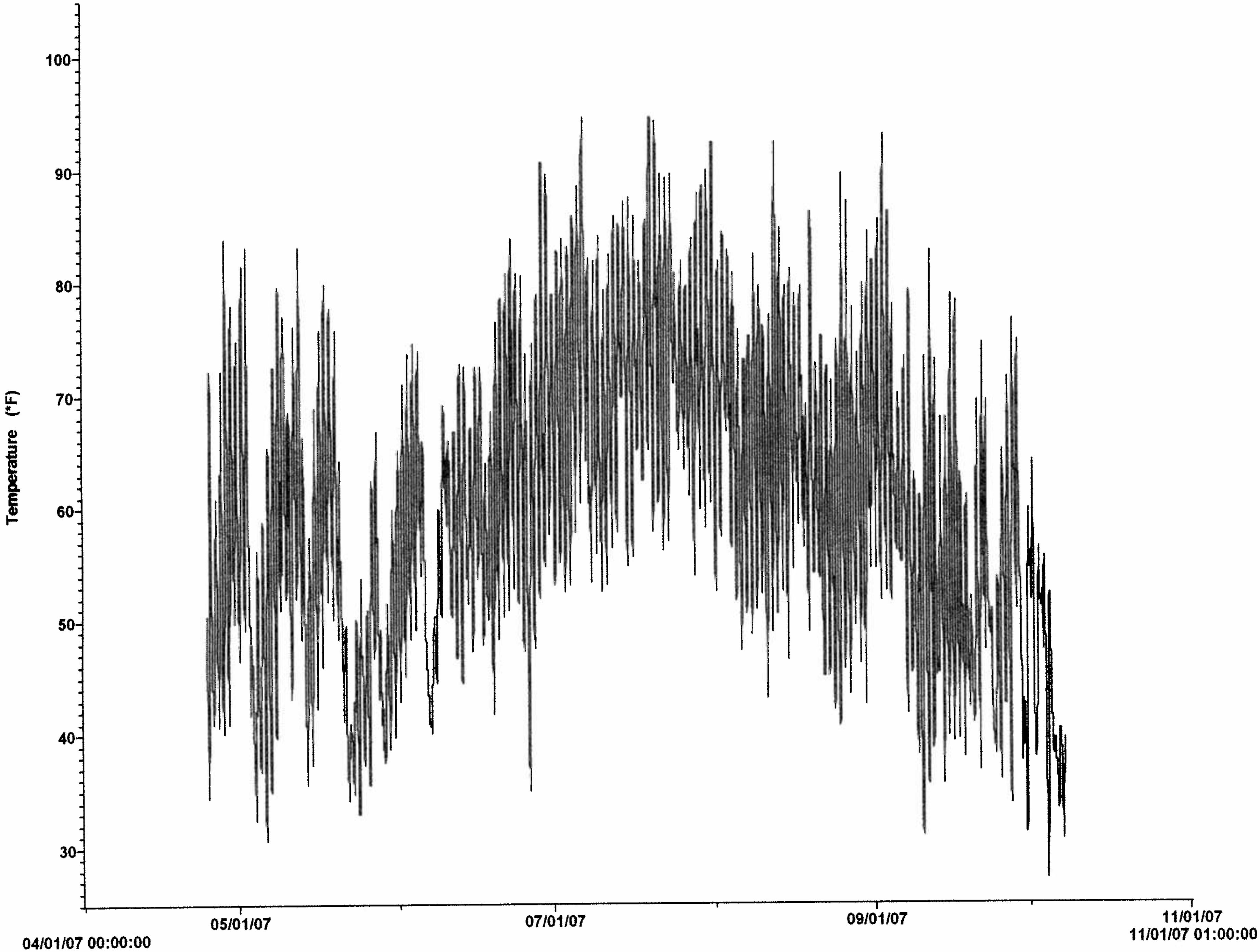



Ennis air
Temperature (*F)
100
90
80
70
60
50
40
30
04/01/07 00:00:00
05/01/07
07/01/07
09/01/07
11/01/07
11/01/07 01:00:00


Ennis Dam air
Temperature (*F)
100
90
80
70
60
50
40
30
04/01/07 00:00:00
05/01/07
07/01/07
09/01/07
11/01/07
11/01/07 01:00:00


Norris air
Temperature (°F)
100
90
80
70
60
50
40
30
05/01/07
07/01/07
09/01/07
11/01/07
04/01/07 00:00:00
11/01/07 01:00:00

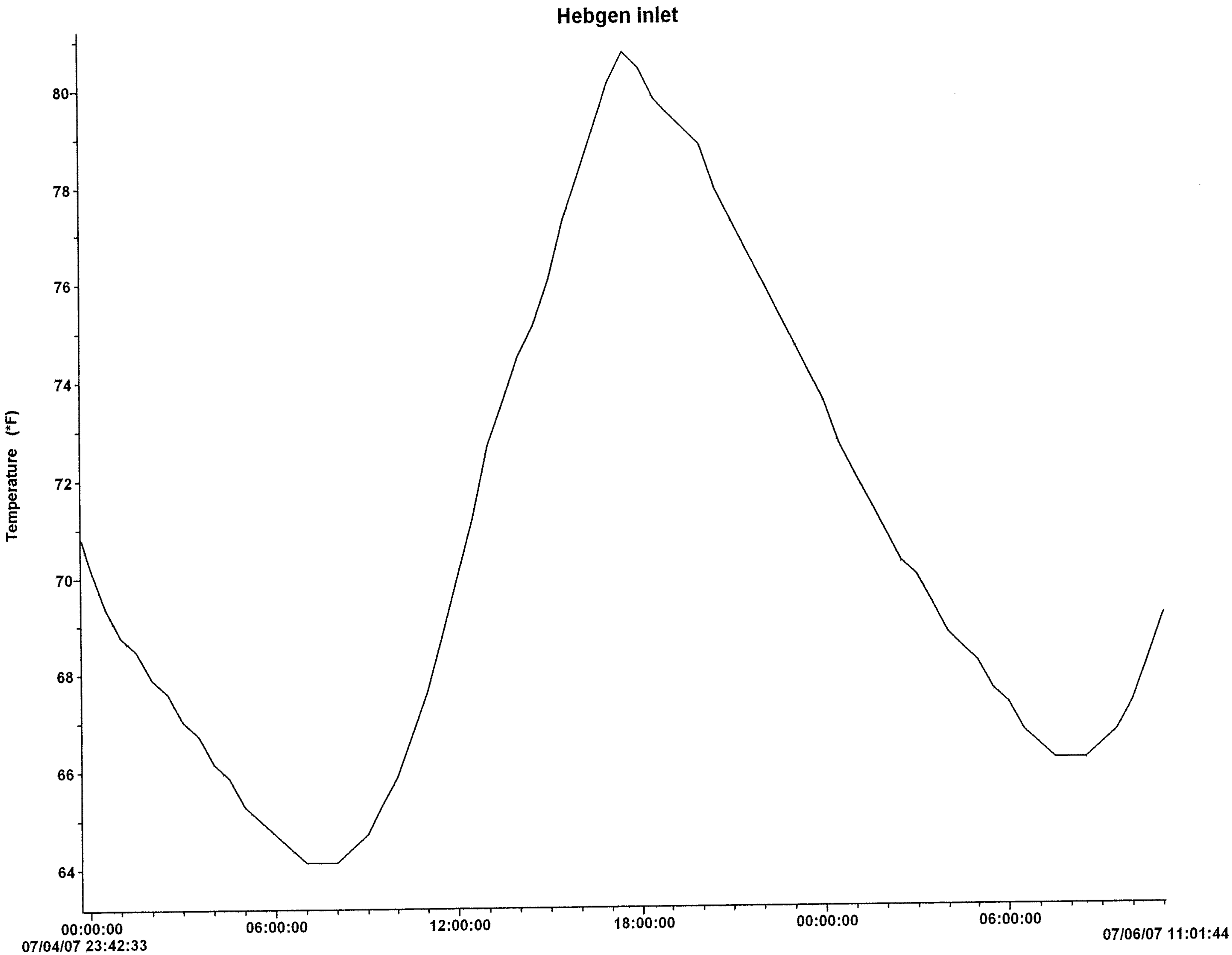
Cobblestone air



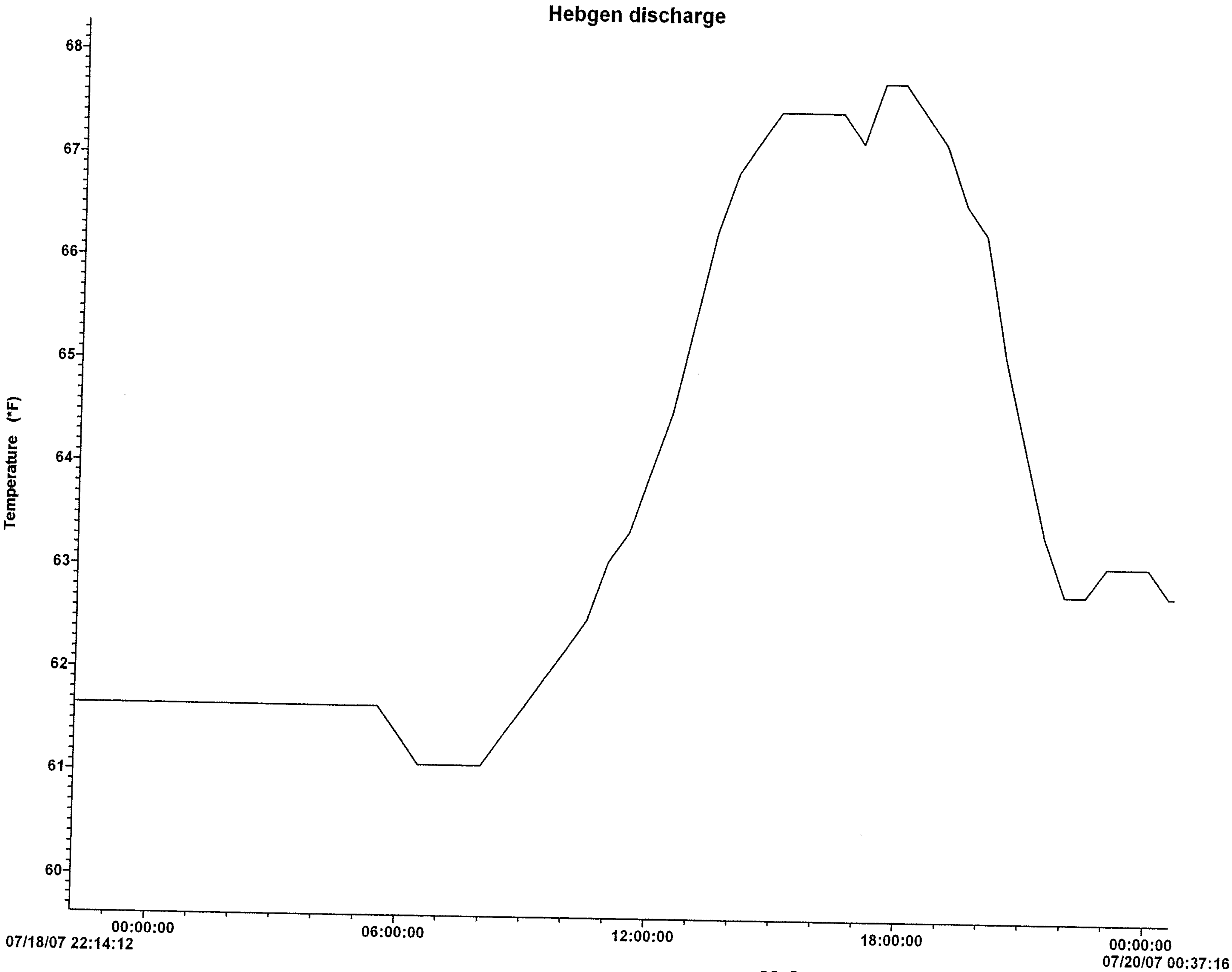
Appendix D2

Diel water temperature fluctuations during the warmest 24 hours at river monitoring sites

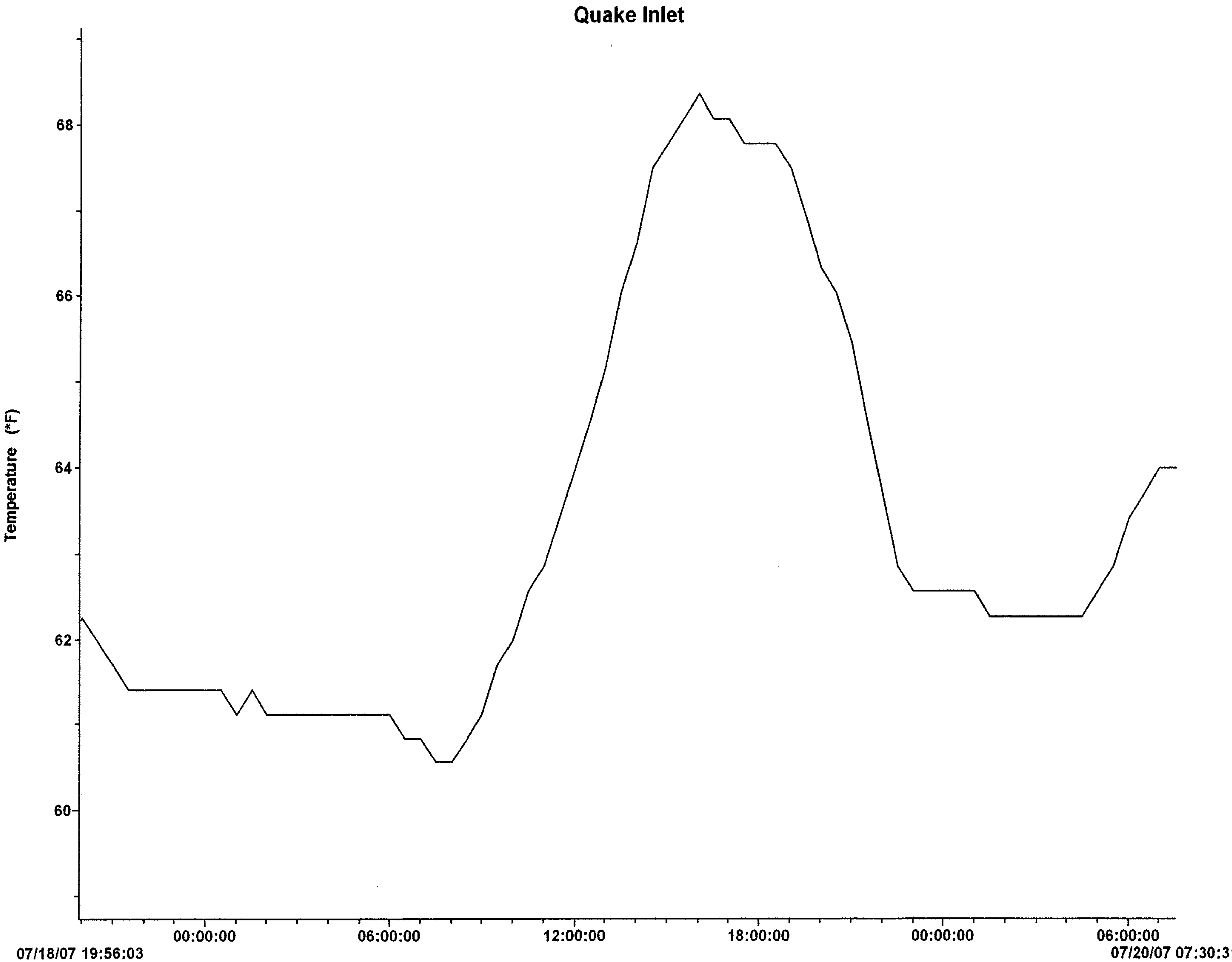
Site	Date	Maximum temperature
Hebgen inlet	July 4	80.74
Hebgen discharge	July 19	67.74
Quake inlet	July 19	68.36
Quake outlet	Aug 31, Sept 2, 3, 4, 5	63.03
Kirby	July 6	71.86
McAtee	July 5	73.44
Ennis Bridge	July 6	76.19
Ennis Reservoir Inlet	July 6	80.05
Ennis Dam	July 7	76.51
Beartrap mouth	July 6, 18	79.09
Norris	July 18	80.30
Black’s Ford	July 6, 18	80.31
Cobblestone	July 6	81.93
Headwaters State Park	July 18	82.08


Hebgen inlet
Temperature (*F)
80
78
76
74
72
70
68
66
64
00:00:00
07/04/07 23:42:33
06:00:00
12:00:00
18:00:00
00:00:00
06:00:00
07/06/07 11:01:44

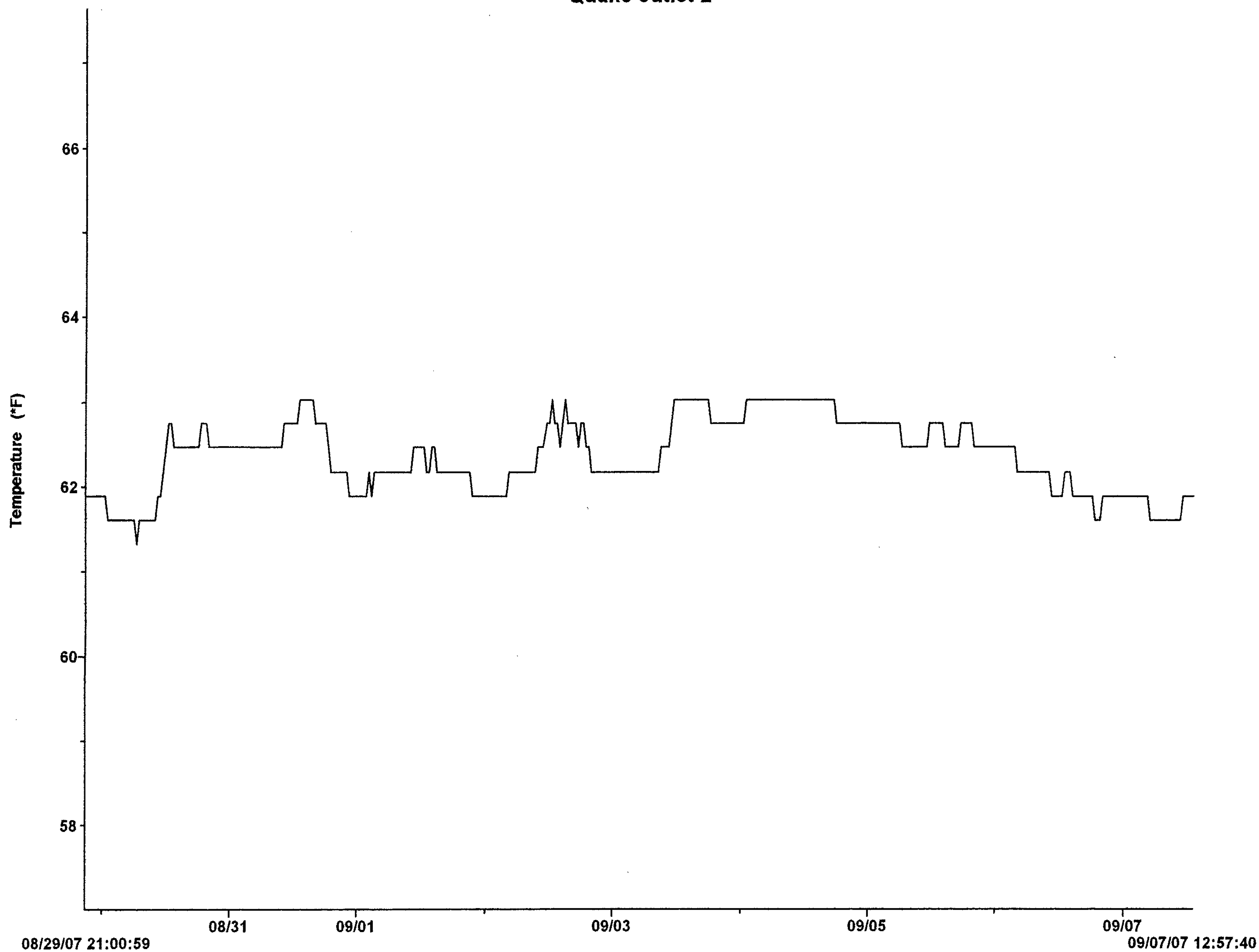
D2-2

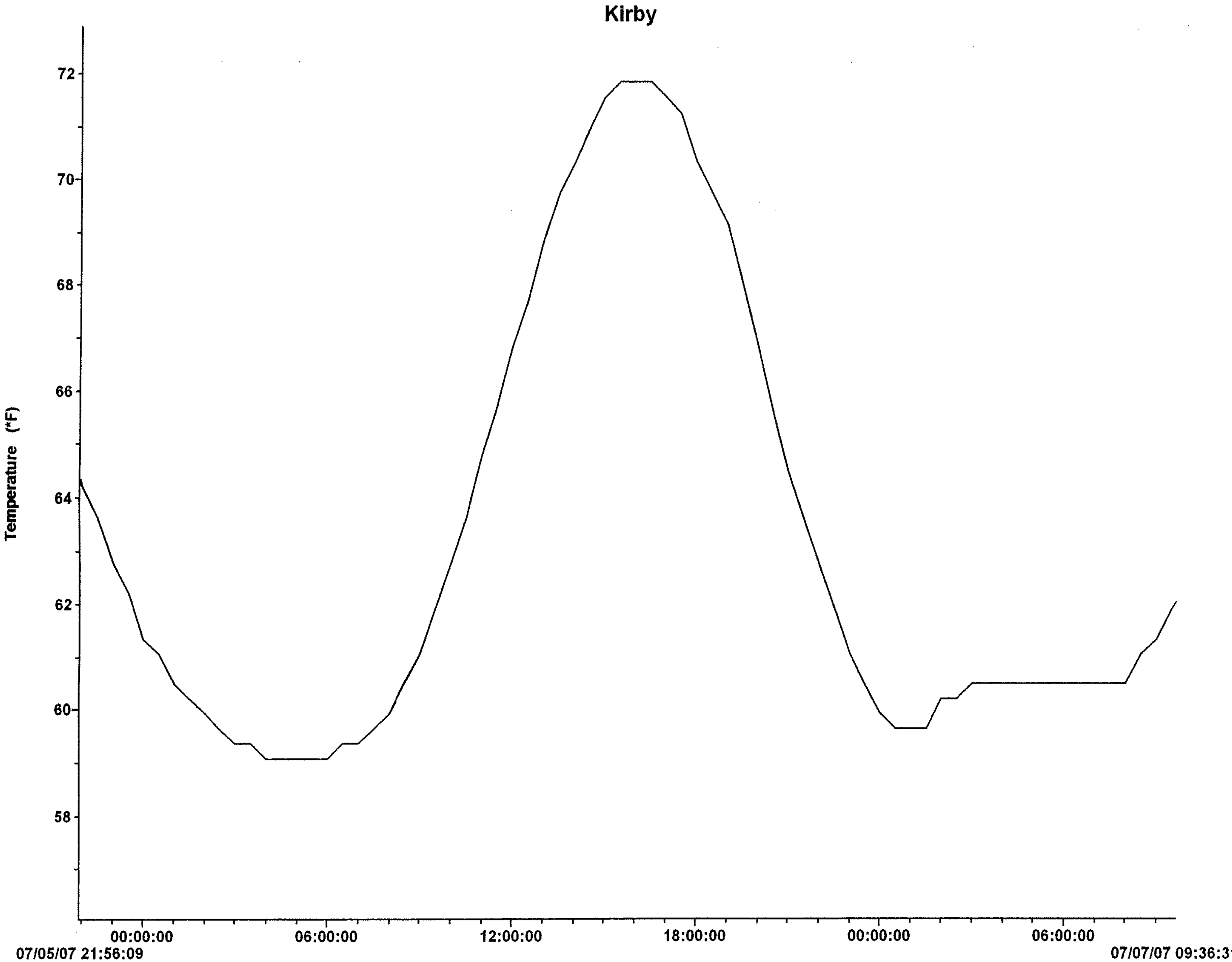

Hebgen discharge
Temperature (*F)
68
67
66
65
64
63
62
61
60
00:00:00
07/18/07 22:14:12
06:00:00
12:00:00
18:00:00
00:00:00
07/20/07 00:37:16

D2-3

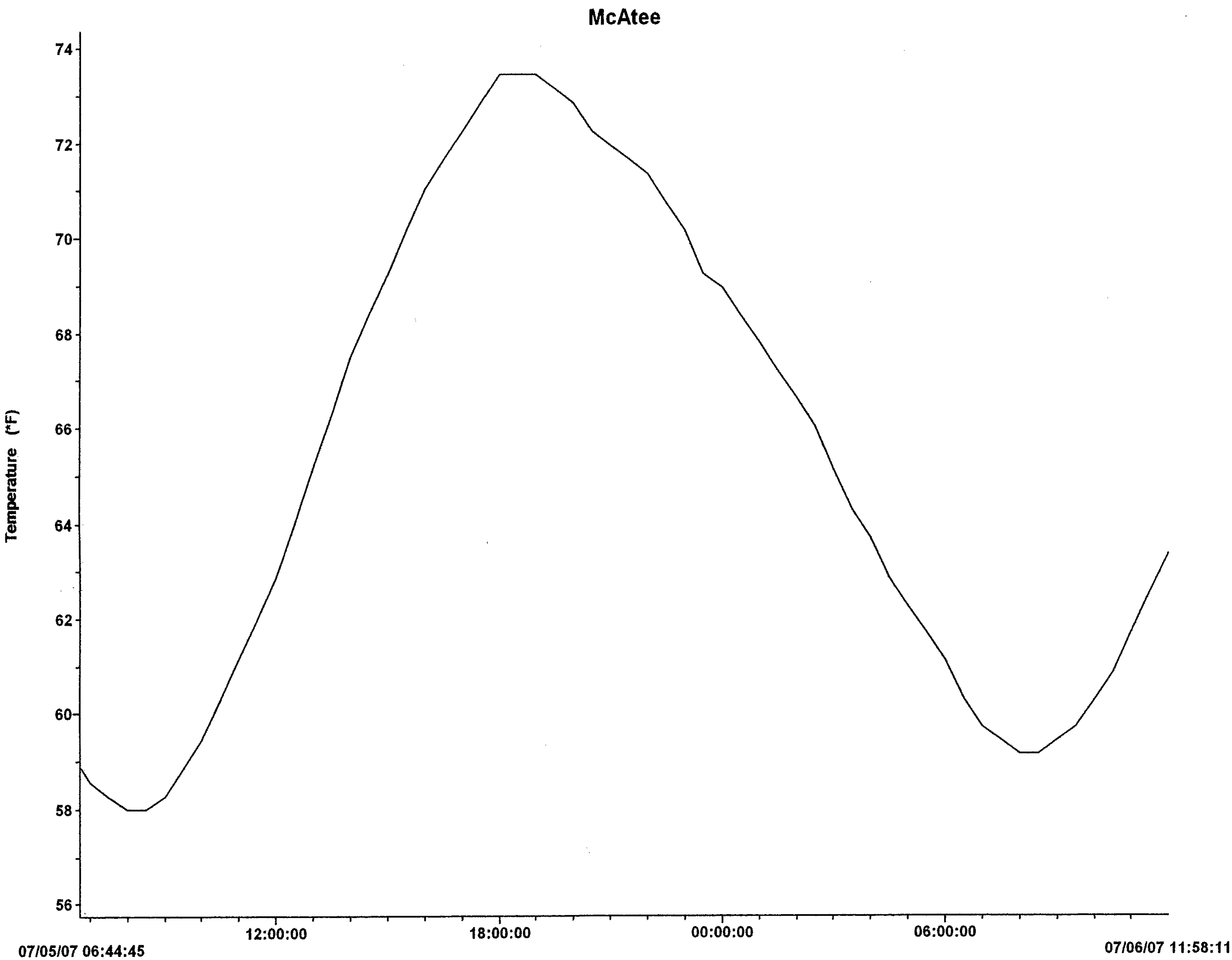

Quake Inlet
Temperature (*F)
68
66
64
62
60
00:00:00
06:00:00
12:00:00
18:00:00
00:00:00
06:00:00
07/18/07 19:56:03
07/20/07 07:30:31

Quake outlet 2





Kirby
Temperature (*F)
72
70
68
66
64
62
60
58
00:00:00
06:00:00
12:00:00
18:00:00
00:00:00
06:00:00
07/05/07 21:56:09
07/07/07 09:36:31


McAtee
Temperature (*F)
74
72
70
68
66
64
62
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58
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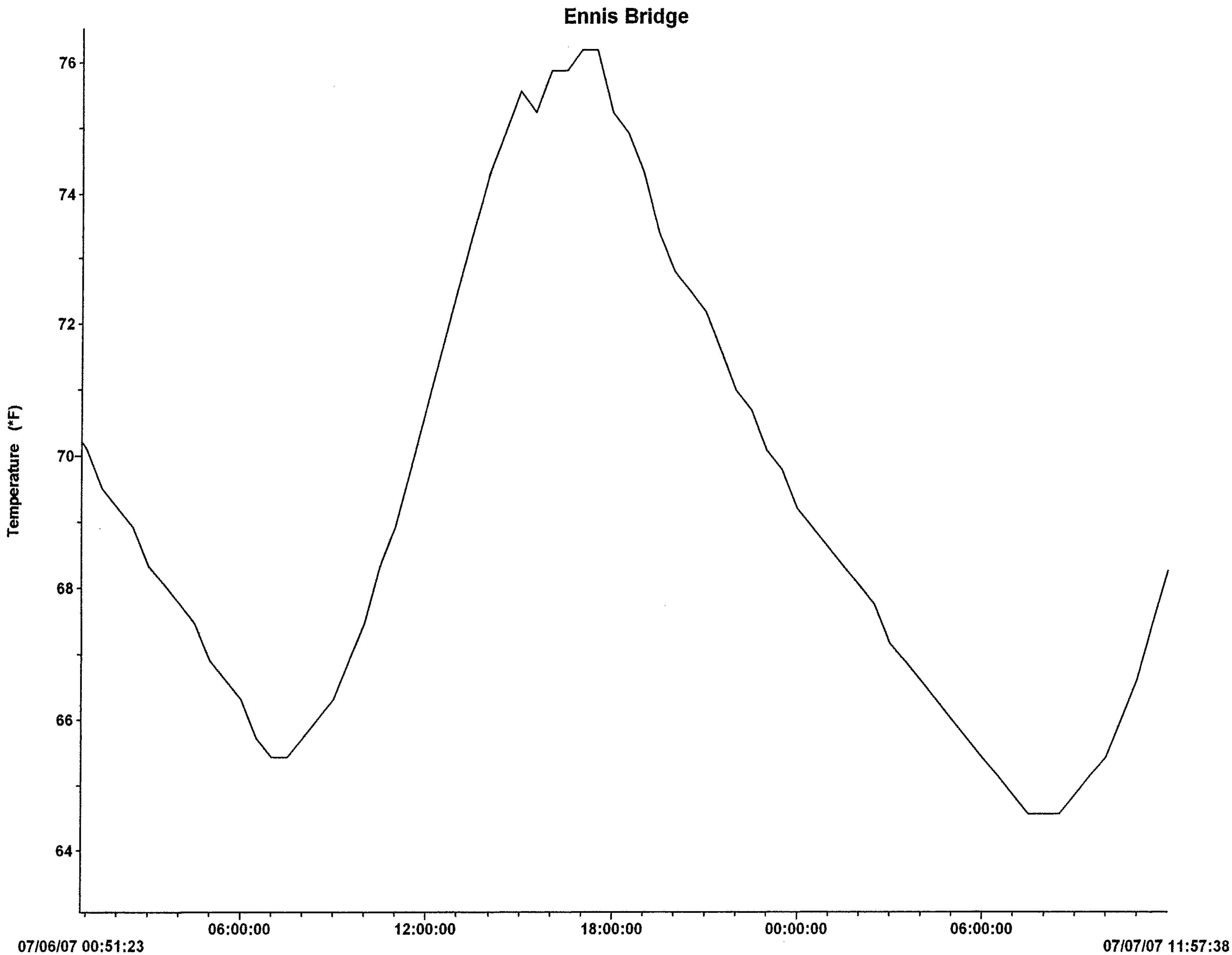

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72
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68
66
64
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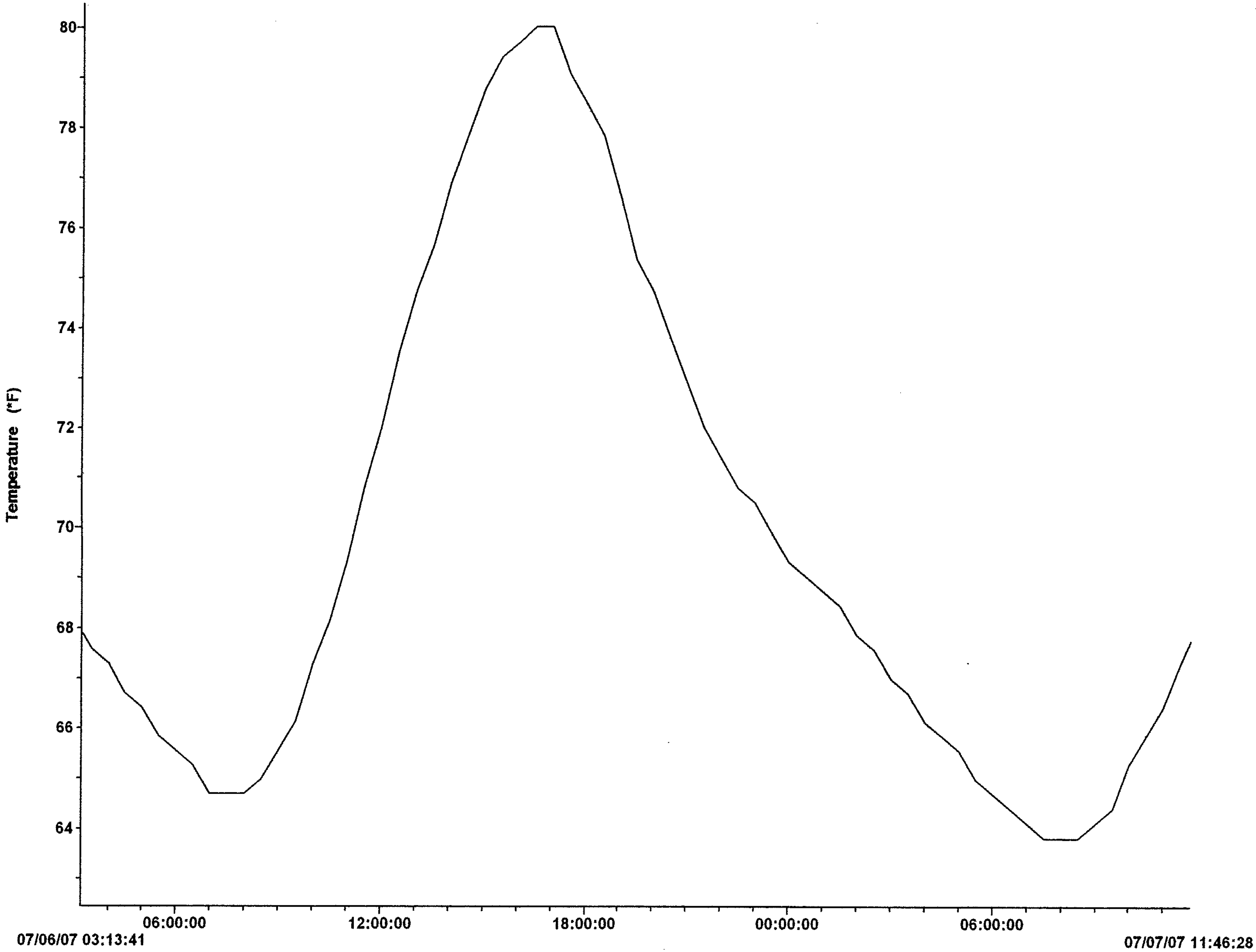

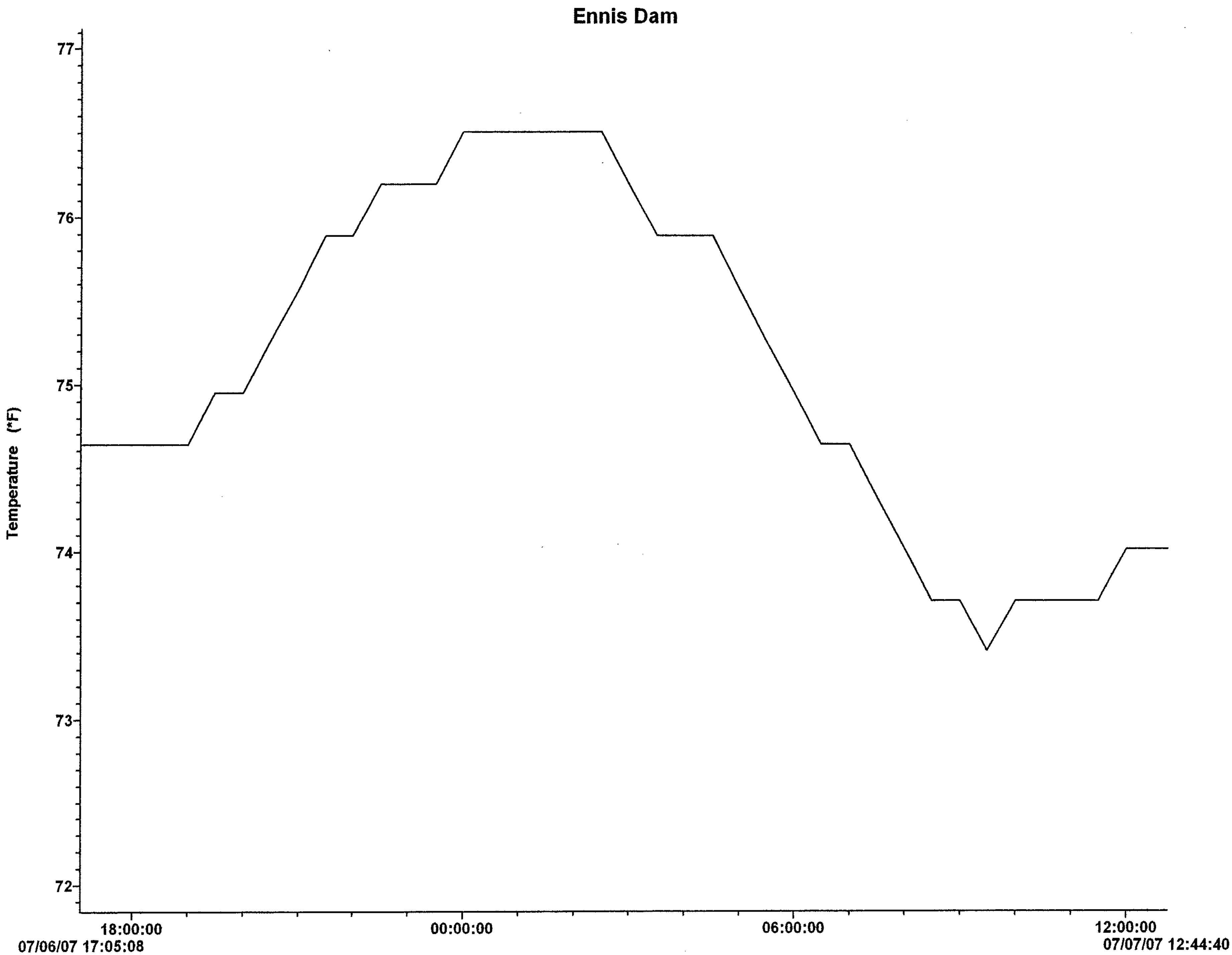
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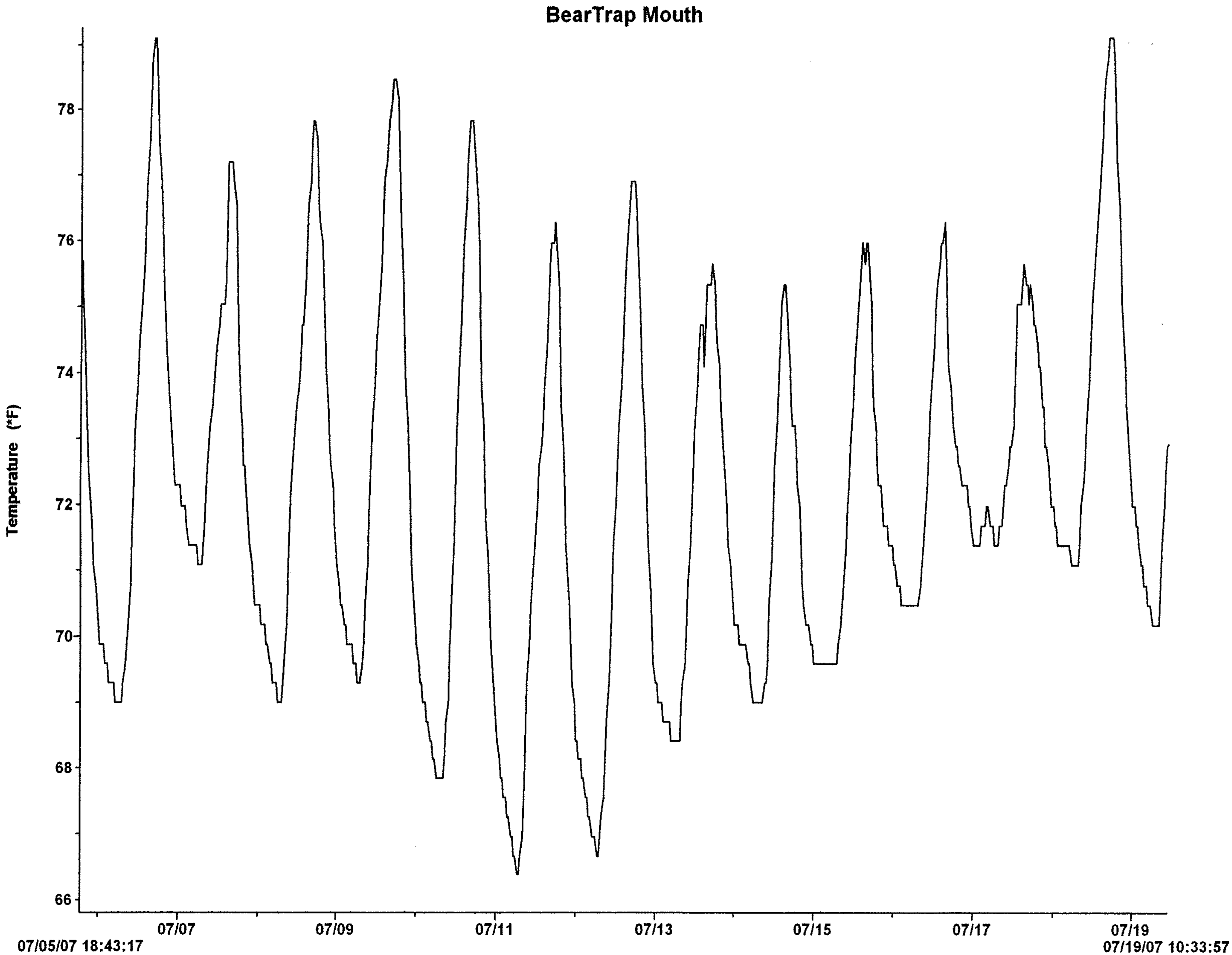
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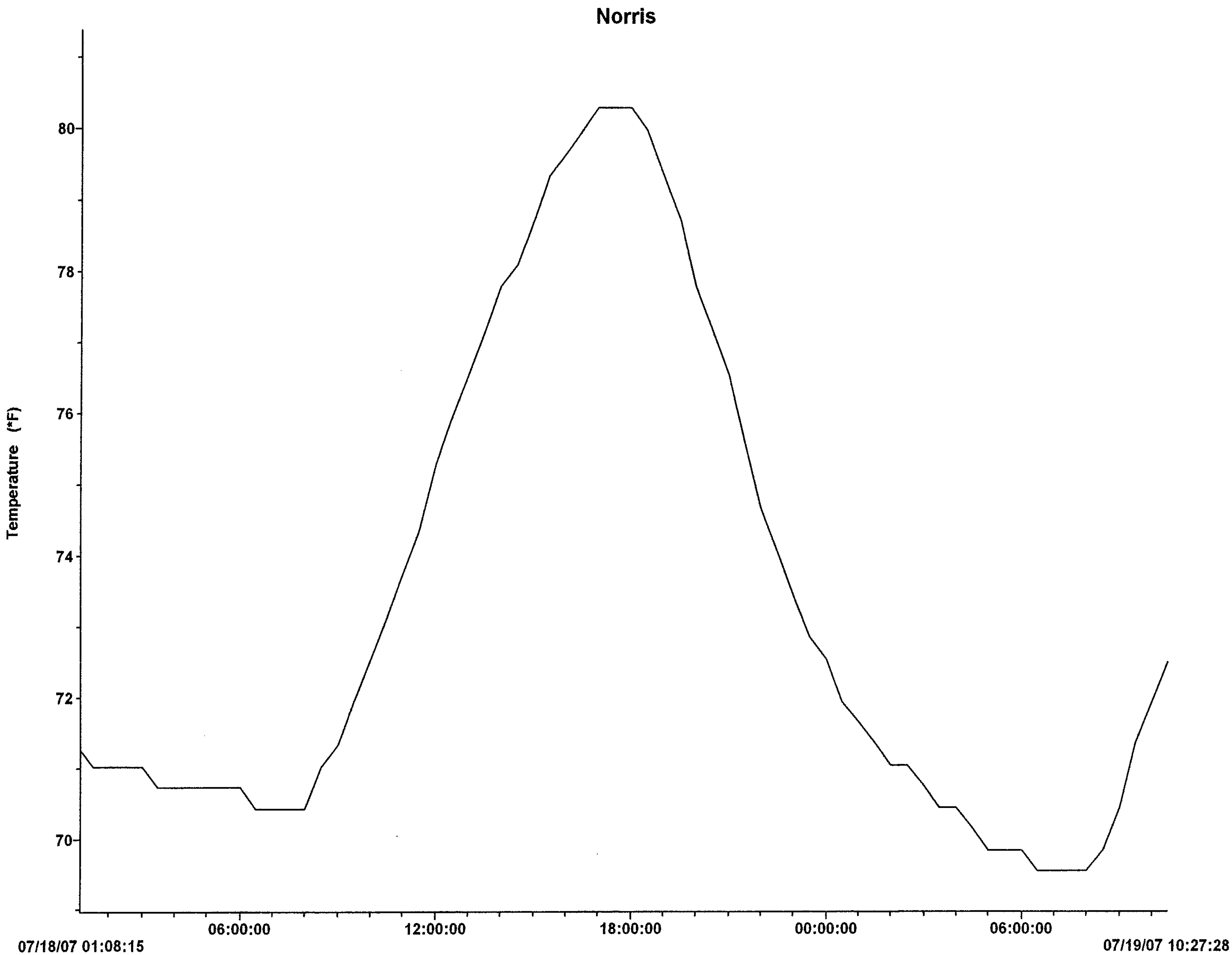

Norris
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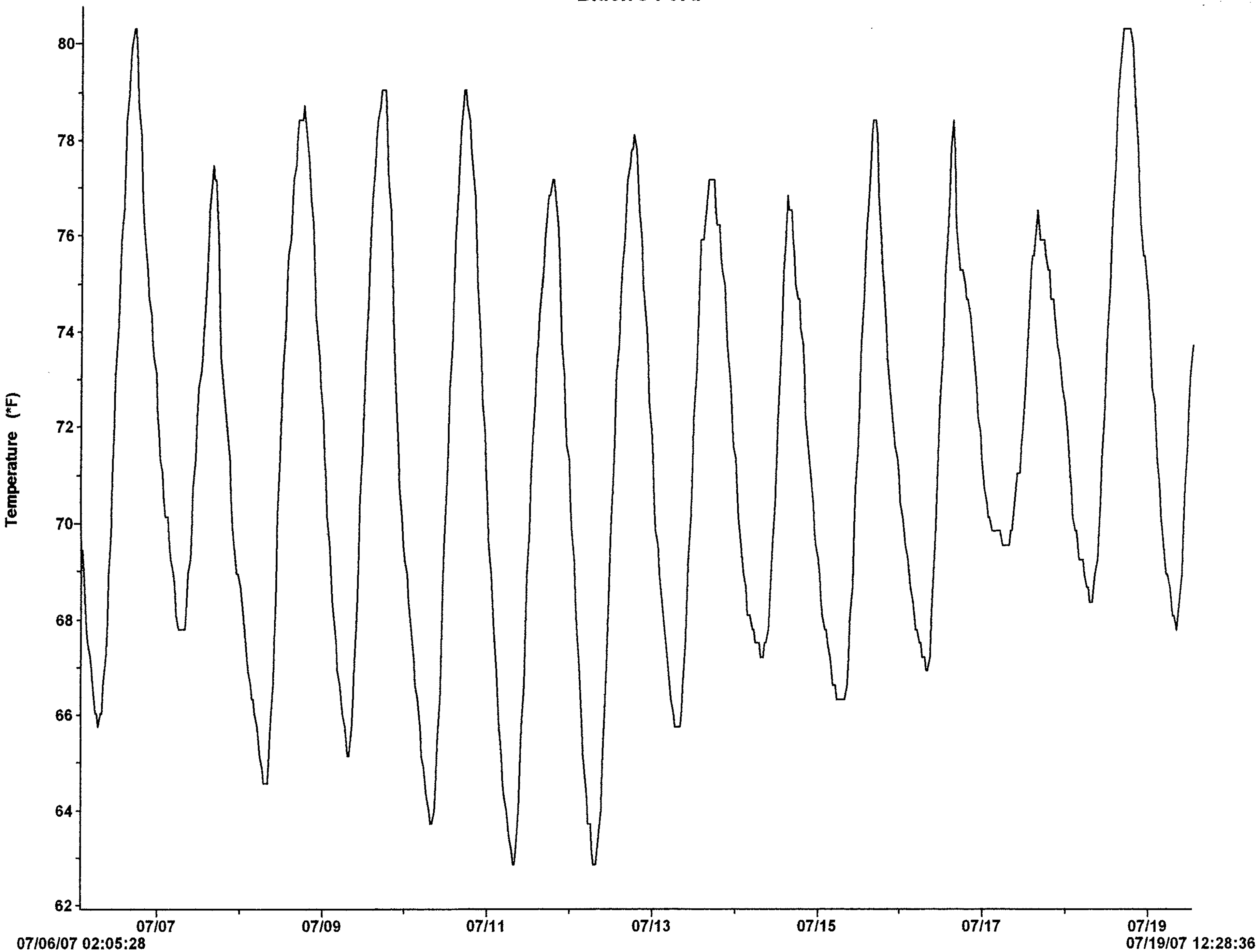
07/19/07 10:27:28

Black's Ford



Black's Ford
Temperature (*F)
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76
74
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68
66
64
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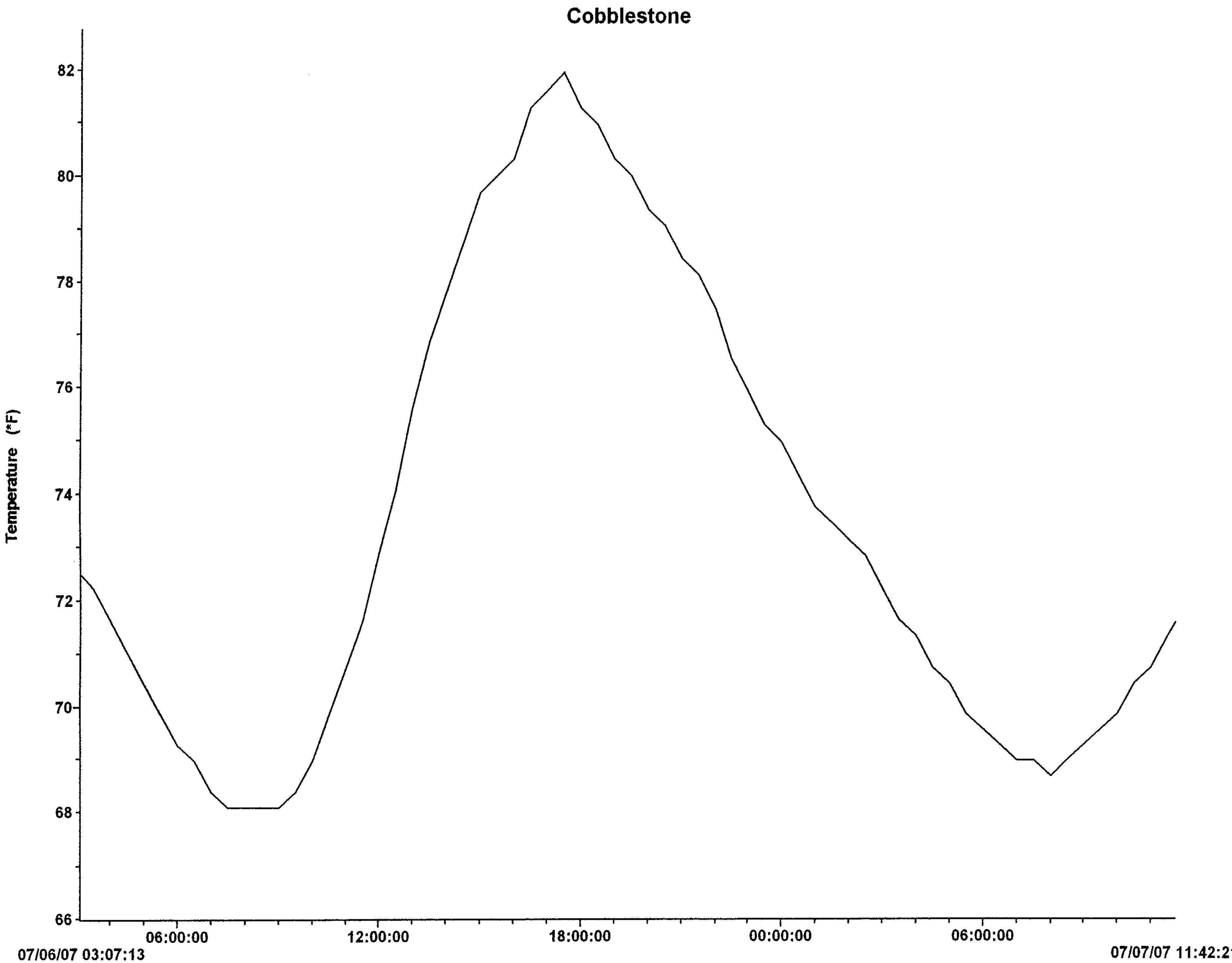
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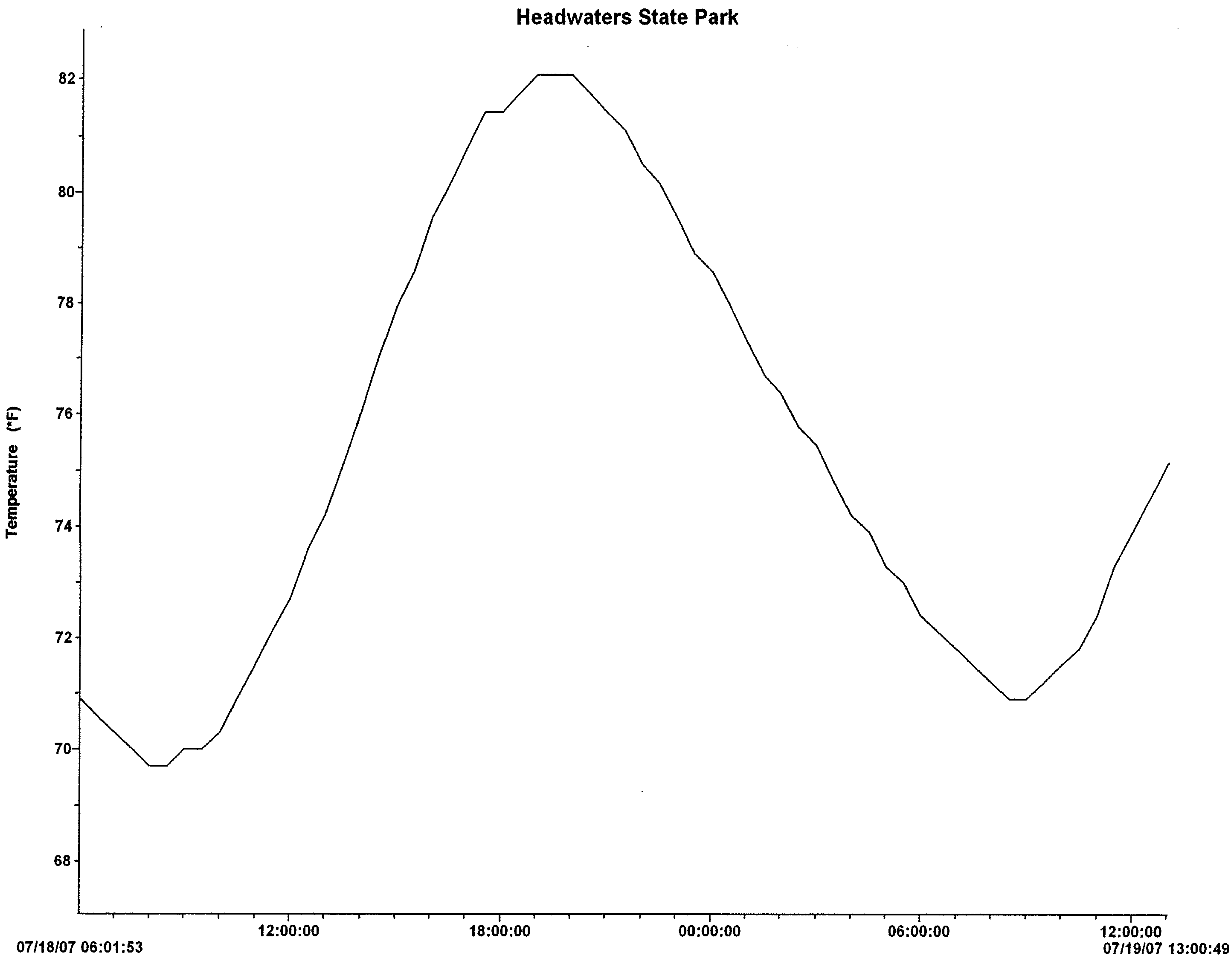
Headwaters State Park
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Appendix E

The Montana Aquatic Nuisance Species Management Plan was finalized in October of 2002 and a full time Aquatic Nuisance Species (ANS) Program Coordinator was hired by Montana Fish, Wildlife and Parks in February of 2004. The emphasis of the Montana ANS Program is on coordination, education, control and prevention of spread, monitoring and detection, and rapid response. The species of emphasis are New Zealand mudsnails, whirling disease, and Eurasian milfoil (all of which are established in Montana), and zebra mussels (which is yet to be documented in the state). Strategies to prevent the further spread and introduction of these species are outlined below.

1. Statewide distribution survey for New Zealand Mudsnails has been completed. All state, federal and private hatcheries have been inspected for New Zealand Mudsnails. One private hatchery contains New Zealand mudsnails, strategies have been implemented to prevent the spread of this invasive through hatchery operations. The spread of New Zealand mudsnails has slowed and appears to be confined to east of the divide.

2. Zebra Mussel veliger sampling has been completed for all major reservoirs on the Missouri River, and on other high priority lakes and reservoirs. To date no zebra mussels have been found within the state.

3. Legislation and Rule making: In 2005 a rule making system was developed to classify exotic wildlife (terrestrial and aquatic) as either non controlled, controlled or prohibited. The following ANS have been since added to the prohibited list: snakehead fish (29 species), grass carp, silver carp, black carp, bighead carp, zebra mussels, rusty crayfish, nutria, African clawed frogs, North American bullfrogs, and New Zealand mudsnails. Legislation was also passed during the 2005 session to provide exceptions for the possession of prohibited species, primarily for the purposes of research, in addition to providing for tougher enforcement authority including the ability to confiscate illegally possessed exotic wildlife.

4. Montana continues to actively participate in the 100th Meridian angler survey program and during 2005 submitted more than 1,700 entries to the angler survey database. The angler surveys are conducted as part of the Montana boat inspection program, which was greatly expanded in 2005. Boat inspections have occurred on all major lakes, reservoirs and popular cold-water trout rivers. The first boat with zebra mussels was found in Montana in March 2005.

5. Training: a one day workshop was provided during the Annual Meeting of the Montana Chapter of the American Fisheries Society on ANS identification, 2 day HACCP workshops have been provided for Montana hatchery personnel and field workers, a half day training was provided for Montana Firefighters on the prevention of spread of ANS, and a half day training was provided on ANS identification and prevention of spread as part of fish health training for fisheries and hatchery personnel within FWS Region 6.

6. Public outreach: presentations on ANS have been made to several special interest groups including Walleyes Unlimited, Fishing Outfitters Association of Montana and Lake Associations. ANS informational booths were present at five Montana outdoor shows: Billings, Bozeman, Great Falls, Missoula and Kalispell. Informational packets have been developed and are being distributed for private pond owners to encourage responsible pond ownership.

7. Illegal introductions: to date over 500 illegal fish introductions have been recorded in Montana. Illegal introductions have been identified as a major source of ANS introductions into Montana waters. An aggressive public outreach campaign was launched during summer of 2005 with an increase in law enforcement to discourage the activity of “bucket biology”.

Appendix F

The MacConnell-Baldwin whirling disease grade-of-severity scale and definitions.

Grade 0: No abnormalities noted. *Myxobolus cerebralis* is not seen.

Grade 1: Small, discrete focus or foci of cartilage degeneration. No or few associated leukocytes.

Grade 2: Single, locally extensive focus or several smaller foci of cartilage degeneration and necrosis. Inflammation is localized, few to moderate numbers of leukocytes infiltrate or border lytic cartilage.

Grade 3: Multiple foci (usually 3 –4[1/]) of cartilage degeneration and necrosis. Moderate number of leukocytes are associated with lytic cartilage. Inflammatory cells extend minimally into surrounding tissue.

Grade 4: Multifocal (usually 4 or more sites[1/]) to coalescing areas of cartilage necrosis. Moderate to large numbers of leukocytes border and/or infiltrate lytic cartilage. Locally extensive leukocyte infiltrates extend into surrounding tissue.

Grade 5: Multifocal (usually 6 or more[1/]) to coalescing areas of cartilage necrosis. Moderate to large numbers of leukocytes border and/or infiltrate necrotic cartilage. The inflammatory response is extensive and leukocytes infiltrate deeply into surrounding tissue. This classification is characterized by loss of normal architecture and is reserved for the most severely infected fish.

[1/] lesion numbers typical for head, not whole body sections.

Appendix G

Madison Ranger District – Aquatic Restoration Partnerships
2007 Monitoring Report

Stream Habitat Restoration Monitoring
Arasta and Gazelle Creeks
Madison Ranger District
Beaverhead-Deerlodge National Forest
2007

Background
Arasta Creek and Gazelle Creek each originate on the east flank of the Gravelly Mountains and flow into the Madison River near Cameron, Montana. The removal of beaver from these drainages, combined with historic overgrazing by livestock, has resulted in considerable down cutting and over-widening of stream channels, along with a relatively high fine sediment load. Each watershed is currently grazed by livestock, although light to moderate trampling with heavy willow browsing continues from high densities of elk and moose.

The goal of channel restoration in these drainages is to reverse its over-widened and down cut channel geometry. The means to accomplishing this objective is to influence natural processes such as sinuosity, fine sediment deposition, stream bank formation, and floodplain connectivity to accelerate the rate of channel recovery, using Zeedyk structures. Secondary objectives include improved watershed function with reduced fine sediment load being exported downstream into the Madison River system, an impaired water body on the MT Department of Environmental Quality's 303d list.

Riffle and baffles were initially installed in these three systems in 2005, with work continuing during the summer of 2007. This project has received considerable funding support from PPL-Montana in each year under the authority of Article 409 of the PPL FERC license on the Madison River, specifically part (3) "fish habitat enhancement both in the main stem and tributary streams, including enhancement for all life stages of fishes" and part (9) "riparian habitat restoration". The Madison-Beaverhead Counties RAC also provided funds toward the purchase of supplies in 2005-7. It is expected that restoration efforts will continue on this reach of project through the summer of 2008, with additional restoration opportunities that could be addressed in future years.

Results observed in 2007 were that all structures survived winter ice and spring flows completely intact and functioning, trapping fine sediment to their potential. Structures again survived intact over the 2006 winter and spring runoff, however no additional sediment appeared to be depositing, leading us to believe the structures functioned to their potential in the first two years. Photographs of structures are inserted below.

Gazelle Creek, channel spanning structures raising stream bed elevation, August 2007.

Fine sediment deposit and point bar expansion, Arasta Creek, July 2007. This structure, installed in 2006, was not holding water after spring runoff. It was repaired using burlap to seal the structure

Same structure after repair, August 2007.

Stream Habitat Restoration Monitoring
Elk River, Madison Ranger District
Beaverhead-Deerlodge National Forest
2007

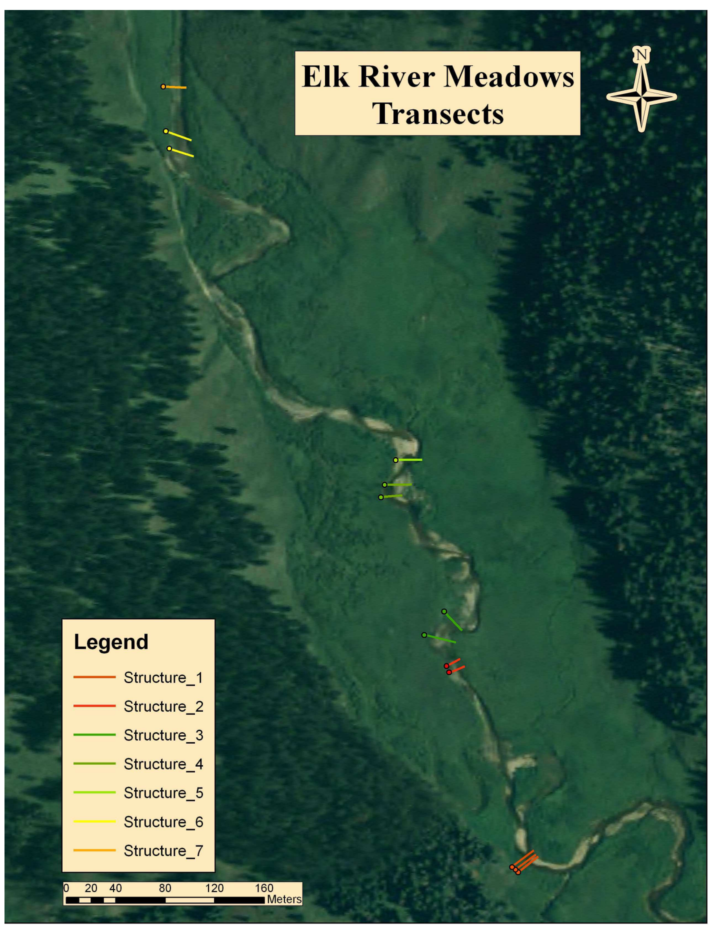
Background

Elk River originates on the east flank of the Gravelly Mountains and flows into the Madison River south of Cameron, Montana. The removal of beaver from this drainage, combined with historic overgrazing by livestock, has resulted in considerable down cutting and over-widening of stream channels, along with a relatively high fine sediment load. The headwaters of this watershed is currently grazed by a band of sheep, with light trampling with heavy willow browsing continues from moderate densities of elk and moose.

The goal of channel restoration in these drainages is to reverse its over-widened and down cut channel geometry. The means to accomplishing this objective is to influence natural processes such as sinuosity, fine sediment deposition, stream bank formation, and floodplain connectivity to accelerate the rate of channel recovery, using Zeedyk structures. One baffle (Structure 1) was installed in 2006, followed by six more in 2007 (see aerial map below). Each are monitored by one or more cross-sectional transects. Secondary objectives include improved watershed function with reduced fine sediment load being exported downstream into the Madison River system, an impaired water body on the MT Department of Environmental Quality's 303d list.

This project has received considerable funding support from PPL-Montana in each year under the authority of Article 409 of the PPL FERC license on the Madison River, specifically part (3) "fish habitat enhancement both in the main stem and tributary streams, including enhancement for all life stages of fishes" and part (9) "riparian habitat restoration". The Madison-Beaverhead Counties RAC also provided funds toward the purchase of supplies in 2007. It is expected that restoration efforts will continue on this reach of project through the summer of 2008, with additional restoration opportunities that could be addressed in future years.

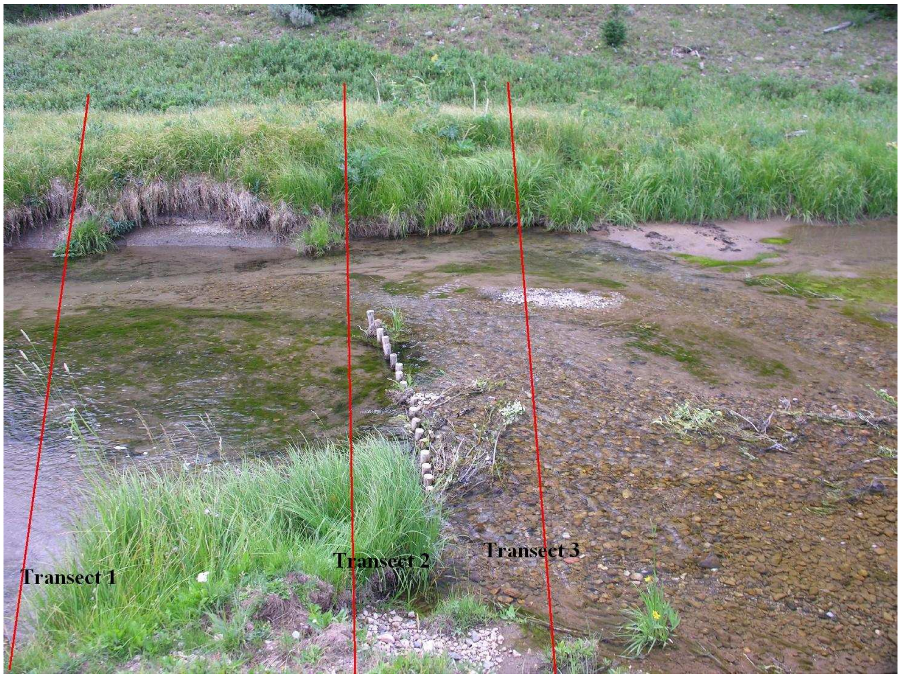
Results observed in 2007 was that the lone structure installed in 2006 survived winter ice and spring flows completely intact and functioning, trapping considerable sediment upstream of its face.



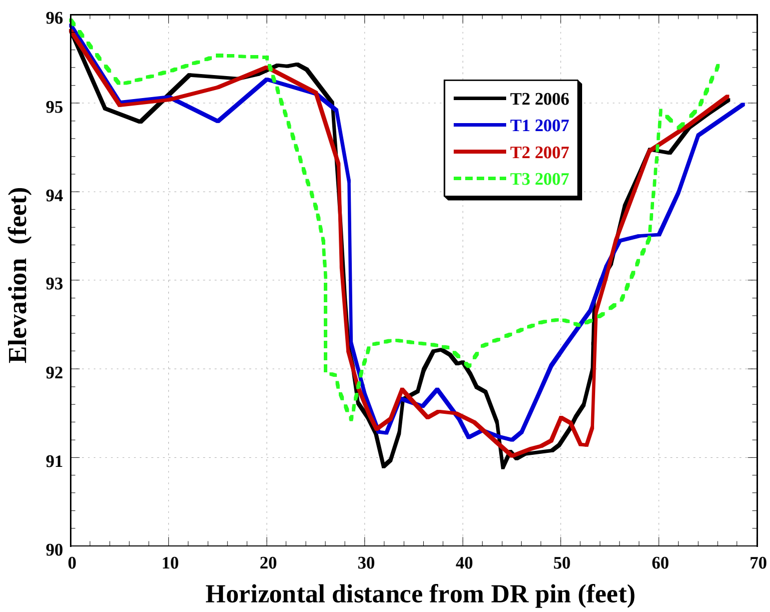
Aerial map of Elk River structure sites and monitoring transects, August 2007.


Structure 1 looking upstream at unconsolidated sediments composing bars in Elk River Meadow, 2005.


Same view, July 2007. Note the deposition of sediments upstream of wood stakes and new thalweg.



Same structure, viewed across the channel. Note the larger sediment composition deposited upstream of the structure, with finer sediments deposited downstream of the structure, and in the back water area in the far upper right corner of the photo. July 2007. Red lines approximate transects of channel cross-sections recorded in 2007, yet to be graphed. Beaver were actively creating dams in this vicinity using small stream side willow, with one small dam partially spanning the stream about 50 feet upstream of this site. About 5 weeks later, this dam fully spanned the channel and was about 1-2 feet tall. Its integrity was questionable, and it is not expected to survive 2008 spring runoff. Farther downstream, a large beaver dam was augmented such that this structure was fully inundated in September.



Graph of channel cross-section transects. Transect 2 was first measured in 2006, and repeated in 2007. Transects 1 and 3 were first measured in 2007. Results indicate no real change in Transect 2 from 2006 to 2007; the large sedge chunk appearing in the 2006 photo (dark black line in graph) was moved and incorporated into the downstream left (DL) bank of Transect 2 (see second and third photos above). It does appear that some mid-channel scour of the streambed occurred immediately downstream of the structure where the sedge chunk was removed from, but overall is fairly limited.

Comparison between Transects 1, 2, and 3 as measured in 2007 are qualitative as there was no common reference point (benchmark) to correct each transect to. However, because the ground surface elevation along the DR bank is fairly level, we adjusted transect elevations to that of Transect 2 at its zero horizontal point, allowing a visual comparison of all three transects in the same graph.

We believe the graph above provides a good representation of how larger sediment has been trapped upstream of the structure (dashed green line) and raised the streambed elevation one to one and a half feet. Sediment also appears to be depositing and raising the streambed along the DR bend where the thalweg is maintained, as evidenced all three 2007 transects.

Stream Habitat Restoration Monitoring
Tepee Creek, Madison Ranger District
Beaverhead-Deerlodge National Forest
2007

Background

Tepee Creek originates on the east flank of the Gravelly Mountains as a tributary to Horse Creek and flows into the Madison River near Cameron, Montana. The removal of beaver from this drainage, combined with historic overgrazing by livestock, has resulted in considerable down cutting and over-widening of the stream channel, along with a very high fine sediment load. Tepee Creek has not been grazed by livestock for about 25 years, although light to moderate trampling with heavy willow browsing continues from high densities of elk and moose associated with the nearby Wall Creek Wildlife Management Area. The treatment segment of Tepee Creek is fishless and upstream of a natural barrier; molecular analyses downstream in Horse Creek indicate that WCT are greater than 90% pure. Once habitat has been restored to acceptable levels in Tepee Creek, there is an opportunity to introduce pure WCT to this headwater tributary.

The goal of channel restoration in Tepee Creek is to reverse its over-widened and down cut channel geometry. The means to accomplishing this objective is to influence natural processes such as sinuosity, fine sediment deposition, stream bank formation, and floodplain connectivity to accelerate the rate of channel recovery. Secondary objectives include improved watershed function with reduced fine sediment load being exported downstream into the Madison River system, an impaired water body on the Montana Department of Environmental Quality's 303d list.

Accomplishment of this goal entails the installation of low-head riffles and baffles using native rock and wooden stakes to influence deposition of fine sediments during springtime high flows (Zeedyk 2006 [1]). The relatively high fine sediment load of Tepee Creek, normally interpreted as a negative, actually provides the natural material to rebuild point bars and stream banks. These structures employ wooden stakes – anywhere from 50-100 cm long – that are pounded into the streambed in a dot-grid matrix, leaving roughly 10-50 cm of the stake protruding above the streambed surface in tributary-scale channels. The interstices formed by the spaces between stakes are then filled with native cobbles and smaller materials to form the riffle or baffle. Stakes provide the integrity to the structure to persist high flows and influence sediment deposition. Riffles are constructed as channel-spanning features, generally installed to influence upstream sediment deposition. Baffles are not intended to span the channel, instead acting to form point bars and increase sinuosity in the channel. Riffles and baffles typically exhibit an elevation gradient across the channel, influencing flow against one bank and deposition against the other bank, particularly in the downstream backwater area.

Riffle and baffles were initially installed in September 2004, with work continuing during the summer of 2007. This project has received considerable funding support from PPL-Montana in each year under the authority of Article 409 of the PPL FERC license on the Madison River, specifically part (3) "fish habitat enhancement both in the main stem and tributary streams, including enhancement for all life stages of fishes" and part (9) "riparian habitat restoration". The Madison-Beaverhead Counties RAC also provided funds toward the purchase of supplies in 2005-6. It is expected that restoration efforts will continue on this reach of project through the summer of 2008, with additional restoration opportunities upstream that could be addressed in future years.

Results

Results observed in 2005 were promising in that all structures survived winter ice and spring flows completely intact and functioning, trapping fine sediment to their potential, as evidenced by channel cross-sections. Structures again survived intact over the 2006 winter and spring runoff, however no additional sediment appeared to be depositing, leading us to believe the structures functioned to their potential in the first year (2005), and that any additional deposition would require adding height to existing structures, or new structures altogether. Hence, in 2006 we added structures in this reach that were considerably taller and spanned the down cut channel from bank to bank (Figure 1). These structures included willow cutting woven between stakes, and were effective in damming flow.

Results in 2007 were quite impressive as significant quantities of fine sediment were trapped upstream of the new dam-like structures installed the previous summer. These structures survived intact; however they suffered small breaches that allowed water to leak through, lowering water surface elevations upstream. We repaired these structures using bio-degradeable sandbags and sedge chunks, which was very effective in holding water levels upstream (Figures 2 and 3).

Zeedyk 2006 – see: http://quiviracoalition.org/images/pdfs/75-Induced_Meandering_Field_Guide.pdf

Figure 1. Channel spanning wicker weirs, located about 100 feet downstream of Riffle #6, Tepee Creek, summer 2006.

Four transects were re-surveyed in Tepee Creek in July 2007. The lower three related stable to slight decreases in streambed elevation relative to the their respective survey in 2006. The upper two transect surveys (T3 and T4), located over and just upstream of Riffle #6, are depicted here (Figures 4 and 5) for comparison with photos presented in Figures 2 and 3.

Transect #3 (Figure 4) shows a slight decrease in streambed elevation, as fine sediment deposited in 2005 and sustained in 2006 has now been partially eroded. Transect #4, immediately upstream of Riffle #6, relates a significant increase in mid-channel deposition of fine sediment.

Photographic comparison of the reach including both of these transects relates the considerable amount of fine sediment deposited throughout the reach since initial structure installation in September 2004. The vast majority of these deposits are a result of the tall wicker-weir structures installed in 2006 that raised water surface elevation for considerable distances, inundating Riffle #6 and influencing deposition and narrowing of the wetted channel.

The sediment deposited to date is generally unconsolidated and prone to being transported downstream under high spring flows. In the summer of 2007 we purchased and planted sedge plugs in these deposits to begin accelerating the process of revegetation of these bare banks. As sedges mature and root masses grow, these deposits will become secure from erosion. At this time it would be appropriate to re-measure bankfull widths in the reach to compare change as a result of restoration. In 2004, bankfull width in this reach was 1.53 +/- 0.44 m. Based on initial results, we expect the channel will narrow to about 0.50 m wide, which would be a decrease of one-third its pre-treatment width.

Figure 2. Tepee Creek, Riffle #6, day of installation, 29 September 2004.

Figure 3. Tepee Creek, view of Baffle #1 (first installed) looking downstream, 14 July 2007.

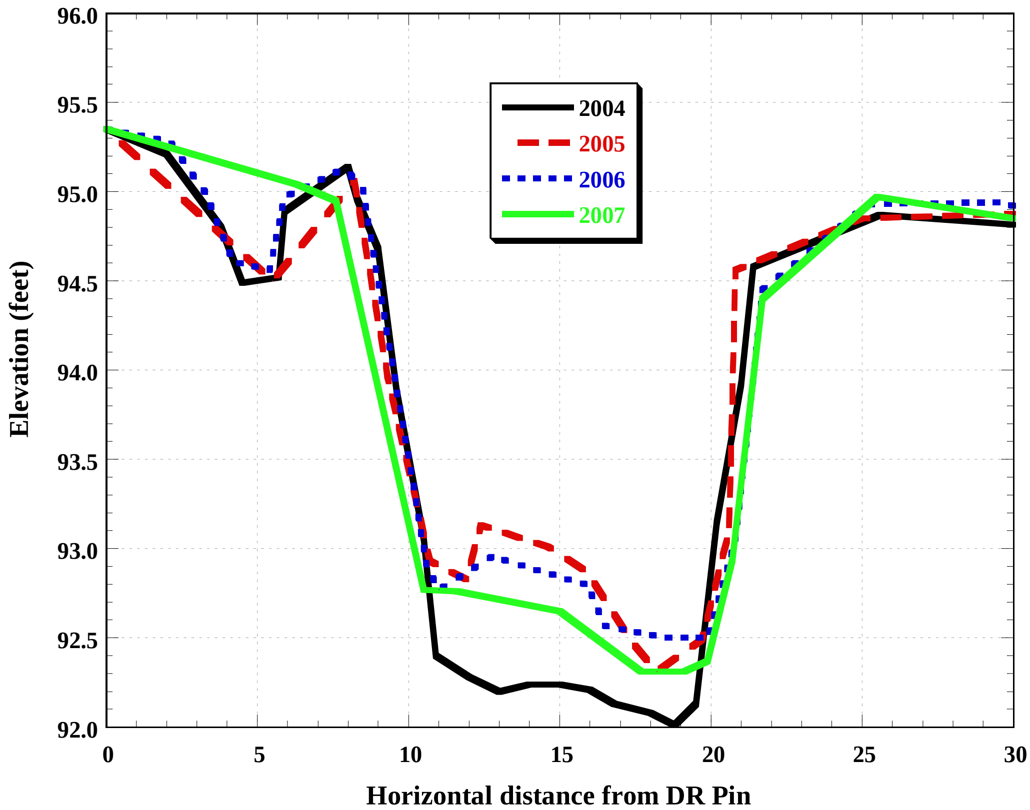


Figure 4. Transect #3, immediately above Riffle #6, note erosion of previously deposited sediment.

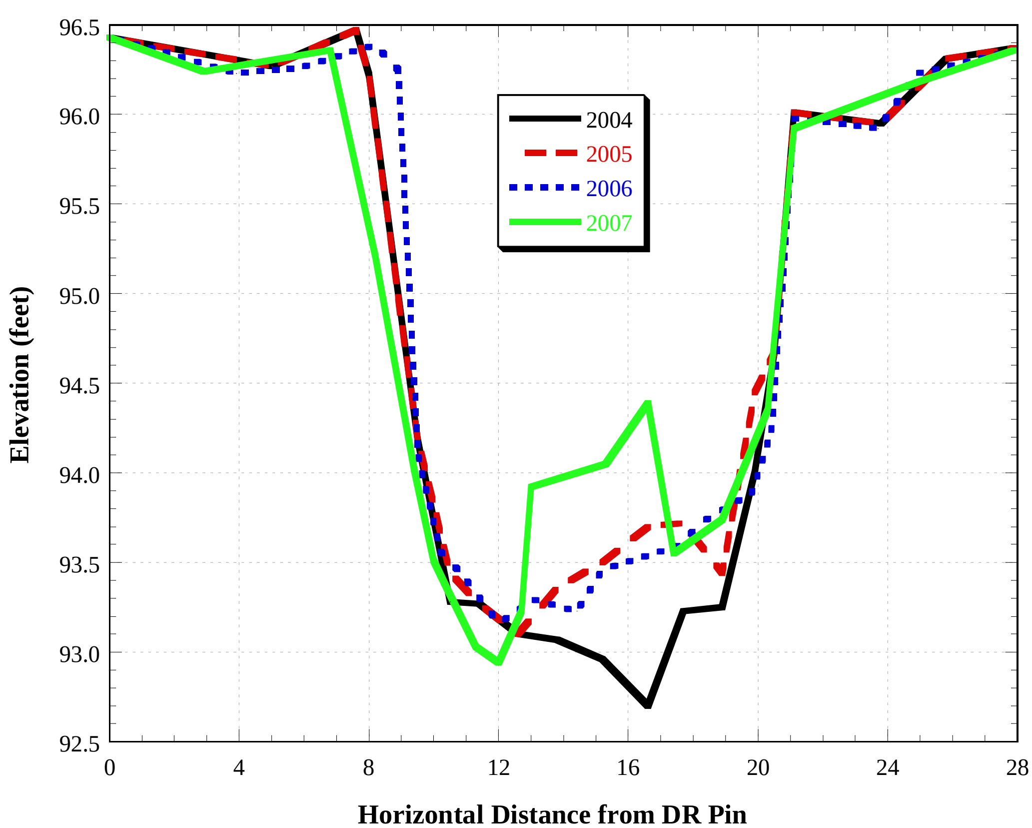


Figure 5. Transect #4, located just upstream of Riffle #6, note sediment deposition mid-channel.

Westslope Cutthroat Trout Habitat Restoration Monitoring
Wigwam Creek, Madison Ranger District
Beaverhead-Deerlodge National Forest
2007

Background

Wigwam Creek originates on the east flank of the Gravelly Mountains and flows into the Madison River near Cameron, Montana. The removal of beaver from this drainage, combined with failed water diversions and historic overgrazing by livestock, has resulted in considerable down cutting and over-widening of the stream channel, along with an elevated fine sediment load. Wigwam Creek is currently grazed by livestock under Amendment 7 riparian standards; light trampling and willow browse occurs from elk and moose densities associated with the nearby Wall Creek Wildlife Management Area. The treatment segment of Wigwam Creek supports a population of WCT; molecular analysis indicates that the genetic integrity of this population varies from 95-82%.

The goal of channel restoration in Tepee Creek is to reverse its over-widened channel geometry. The means to accomplishing this objective is to influence natural processes such as sinuosity, fine sediment deposition, stream bank formation, and floodplain connectivity to accelerate the rate of channel recovery. Secondary objectives include improved watershed function with reduced fine sediment load being exported downstream into the Madison River system, an impaired water body on the Montana Department of Environmental Quality's 303d list.

Accomplishment of this goal entails the installation of low-head riffles and baffles using native rock and wooden stakes to influence deposition of fine sediments during springtime high flows (Zeedyk 2006 [1]). The elevated load of fine sediment in Wigwam Creek, normally interpreted as a negative, actually provides the natural material to rebuild point bars and stream banks. These structures employ wooden stakes – anywhere from 50-100 cm long – that are pounded into the streambed in a dot-grid matrix, leaving roughly 10-50 cm of the stake protruding above the streambed surface in tributary-scale channels. The interstices formed by the spaces between stakes are then filled with native cobbles and smaller materials to form the riffle or baffle. Stakes provide the integrity to the structure to persist high flows and influence sediment deposition. Riffles are constructed as channel-spanning features, generally installed to influence upstream sediment deposition. Baffles are not intended to span the channel, instead acting to form point bars and increase sinuosity in the channel. Riffles and baffles typically exhibit an elevation gradient across the channel, influencing flow against one bank and deposition against the other bank, particularly in the downstream backwater area.

Riffle and baffles were initially installed in September 2004, with work continuing during the summer of 2007. This project has received considerable funding support from PPL-Montana in each year under the authority of Article 409 of the PPL FERC license on the Madison River, specifically part (3) "fish habitat enhancement both in the main stem and tributary streams, including enhancement for all life stages of fishes" and part (9) "riparian habitat restoration". The Madison-Beaverhead Counties RAC has also provided funds toward the purchase of supplies in 2005-7; funding and volunteer labor have been provided by the Madison River Foundation and the Madison-Gallatin chapter of TU . Restoration efforts in this treatment reach are close to complete; additional restoration opportunities upstream could be addressed in future years.

Results

Monitoring of morphological parameters indicate that this restoration technique has been successful in narrowing the channel (bankfull width) and creating more pool habitat (pool frequency) for WCT (Table 1). Pool quality, evaluated using the residual pool depth index, indicates stable or slightly reduced quality, however the expectation is that pools should scour deeper in future years as structures continue to mature and additional high flow events influence scouring. Other changes detected have been a reduction in channel gradient, along with an increase in channel length and sinuosity.

Zeedyk 2006 - http://quiviracoalition.org/images/pdfs/75-Induced_Meandering_Field_Guide.pdf

Table 1. Channel characteristics, Wigwam Creek, 2004-2007

Channel characteristic	2004	2005	2006	2007
Channel length (m)	405	440	437	489
Stream bed gradient (%)	2.45	2.25	2.28	2.03
Sinuosity	1.02	1.11	1.10	1.23
Mean bankfull width (m)	2.65	2.51	2.29	2.04
Pool frequency (pools / km)	24.7	34.1	34.3	49.1
Pool spacing	15.3	11.7	12.7	10.0
Mean residual pool depth (m)	0.23	0.21	0.22	0.21

Baffles installed in Wigwam Creek have been very successful influencing sediment deposition, particularly in their downstream eddy areas. In 2006 and 2007, we purchased sedge plugs and planted them in these areas of deposition to help stabilize these unconsolidated sediments. Sedges appear to thrive in these environments, and continued monitoring will be needed to determine how effective they are in sediment stabilization (Figure 1). Figures 2 and 3 depict how structures have narrowed the Wigwam Creek channel, inducing meandering (sinuosity), creating gravel sorting and pool formation .

Figure 1. Wigwam Creek immediately downstream of the FS Road 290 bridge; previous to baffle installation (July 2005) at left, and after baffle installation (September 2006) at right.

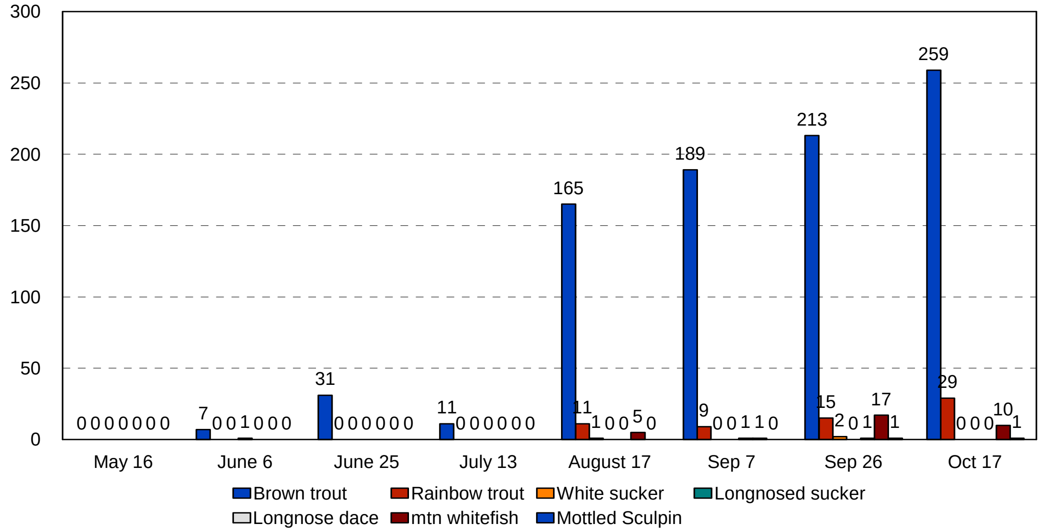
Figure 2. Comparison photos of Wigwam Creek upstream of the bridge. Photo on the left is pre-treatment in 2004, the photo on the right (2007) is after structure installation in the fall of 2006 and one spring run-off event. Note the fine sediment deposition downstream of the structure at lower left, and pool scour immediately downstream. The pasture fence in this reach is old, in disrepair, and slated for replacement in the next year as an exclosure. Due to the nature of local topography and water availability, the project area has had problems with cattle aggregating in the stream and riparian area. Installation of an improved exclosure system should reduce these impacts and further accelerate channel restoration.

Figure 3. Restored channel segment of Wigwam Creek upstream of the bridge. White lines approximate the pre-treatment location of channel banks. Note how structures have reduced channel width and increased sinuosity. The large rocks at lower left were embedded at the outside bend (at right) of the channel, preventing lateral pool scour and leading to channel straightening. Re-locating these rocks (manually) to the inside of the bend has influenced sediment deposition, point bar formation, and lateral pool scour.

Appendix H

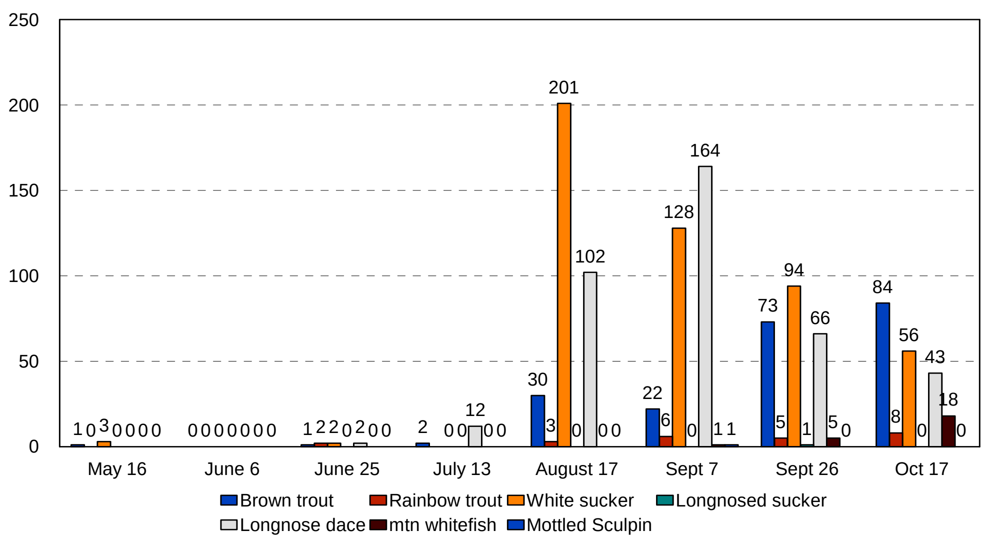
West Madison Canal Fish Entrainment

8 Mile



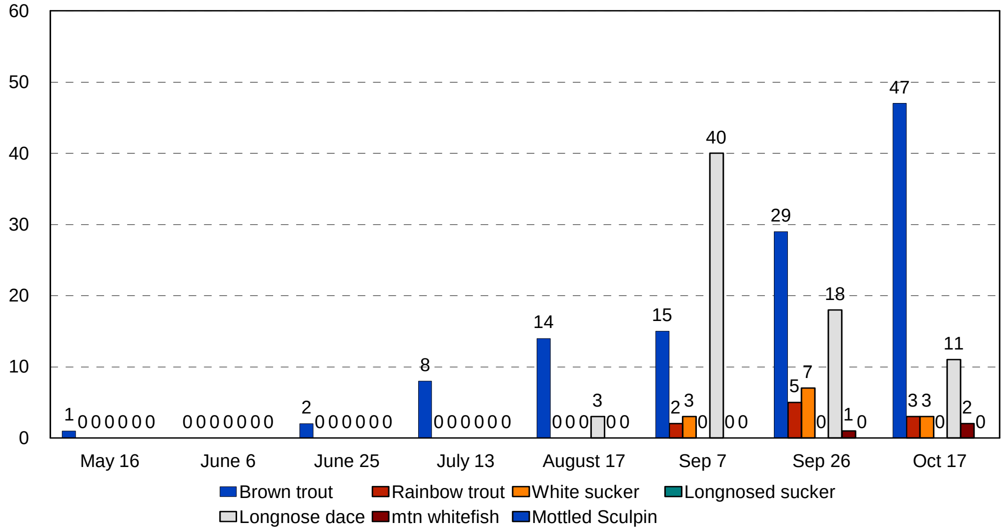
approx 1 mile below headgate; 19-inch brown tagged Sept 7 in Willow Ranch recapped Oct 17 in 8 Mile

Willow Ranch



approx 4 miles below headgate; 19-inch brown tagged Sept 7 in Willow Ranch recapped Oct 17 in 8 Mile

Range View Road



approx 8 miles below headgate