# Madison River Drainage Fisheries

# and

# Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program

## 2011

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, OR OF LOCAL INTEREST
(in alphabetical order)

Aquatic Nuisance Species Task Force.....www.anstaskforce.gov
Blue Ribbon Flies .....www.blueribbonflies.com
Madison River Foundation .....www.madisonriverfoundation.org
Lower Madison River Monitoring page .... www.madisondss.com/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 or .com
Whirling Disease Foundation.....www.whirling-disease.org

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# EXECUTIVE SUMMARY

No young-of-the-year Arctic grayling or whitefish were captured in a screw trap in the Channels section of the Madison River in Spring 2011. Four young-of-the-year whitefish were captured during Ennis Reservoir beach seining in October 2011. Other species captured at seining index sites were Rocky Mountain (mottled) sculpin, brown and rainbow trout, Utah chub, white suckers, longnose dace and fathead minnows. Long-term population trends are displayed for rainbow and brown trout in three river sections. Water temperature was monitored at 15 sites and air temperature at 7 sites within the Madison Drainage. One spring creek, several sites in Hebgen and Ennis reservoirs and numerous Madison River Fishing Access Sites were sampled for New Zealand mud snails and selected other aquatic nuisance species by FWP ANS staff in 2011. No New Zealand mud snails, Eurasian Watermilfoil or juvenile or adult Zebra or Quagga mussels were detected in the river or reservoirs, though NZMS were found in high abundance is the spring creek. Sentinel fish from hatchery rainbow trout stock are still severely infected by whirling disease when placed in cages in the river, but the wild rainbow trout population has rebounded to approximately 60 percent of its pre-whirling disease level. Spawning season movements of radio implanted rainbow trout in 2010 and 2011 are reported. Fisheries monitoring was conducted on Jack, Watkins and the South Fork of Meadow creeks and the South Fork of the Madison River as part of stream channel restoration and habitat improvement projects. The Sun Ranch hatchery was used to incubate westslope cutthroat trout eggs for introduction into three streams, including one in Yellowstone National Park, and into the Sun brood pond. Introduction of genetically pure westslope cutthroat trout continued in the Cherry Creek Drainage in 2011, including Cherry Lake. No non-native fish were observed or captured during widespread electrofishing throughout the Cherry Creek Project area in 2011. Monitoring of the Cherry Creek fish population below the project area where rotenone caused an unintended fish kill in 2010 showed significant recovery of trout numbers, but both rainbow and brown trout larger than 14 inches are still scarce in that section. The number of rainbow trout captured during annual Hebgen Reservoir gillnetting decreased for the third consecutive year, though average length remained high. The proportion of rainbow trout over 14 inches in the Hebgen gillnet catch has increased noticeably since 2005. Zooplankton density in Hebgen Reservoir was monitored.

# FERC Articles addressed in this report

| FERC Article | item | report topic | page number Methods | page number Results |
|---|---|---|---|---|
| 403 | NA | River Discharge | 9 | 36 |
| 408 | (1) | Hebgen gillnetting, disease monitoring - Effect of project operations on fish populations | 20 | 47 |
| | (3) | Reservoir drawdown effects on fish populations | 20 | 47 |
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## INTRODUCTION

Montana Fish, Wildlife, & Parks (FWP) 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, Clancey 1995, Clancey 1996, Clancey 1997, Clancey 1998a, Clancey 1999, Clancey 2000, Clancey and Downing 2001, Clancey 2002, Clancey 2003, Clancey 2004, Clancey and Lohrenz 2005, Clancey 2006, Clancey 2007, Clancey 2008, Clancey and Lohrenz 2009, Clancey and Lohrenz 2010, Clancey and Lohrenz 2011). 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 FWP 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 PPL Montana mitigation funds address the requirements of PPL Montana's Federal Energy Regulatory Commission (FERC) license for operating the Madison & Missouri dams. The Madison Fisheries Technical Advisory Committee (MadTAC) is composed of personnel of PPL Montana, FWP, the U.S. Fish & Wildlife Service (USFWS), the U.S. Forest Service (USFS), and the U.S. Bureau of Land Management (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 FERC license number that authorizes their operation. The FERC issued PPL Montana a license to operate the 2188 Project for 40 years (FERC 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 (WCTA). This agreement, which was formalized in 1999 (Montana FWP 1999), 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

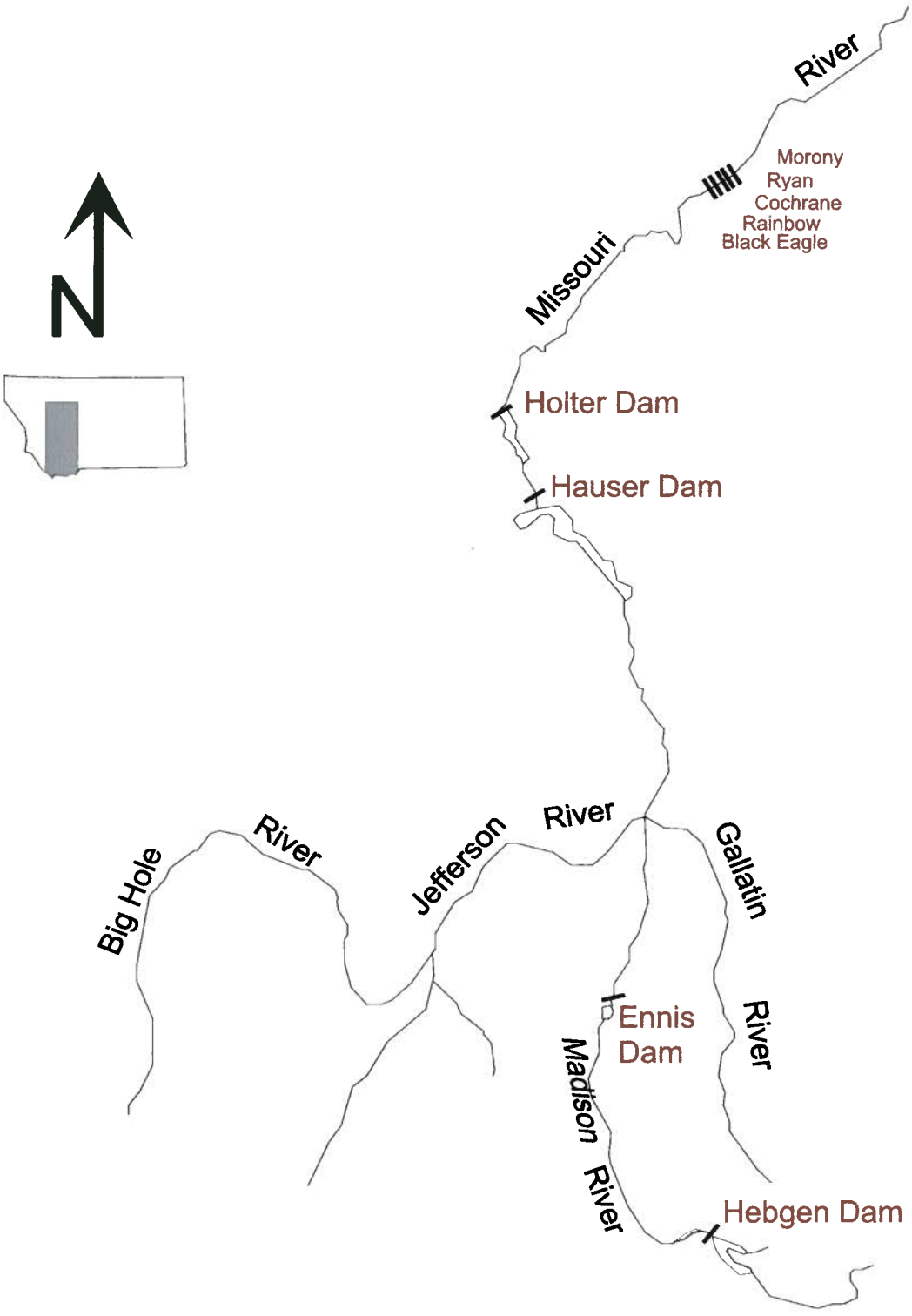


Figure 1. Map showing locations of PPL Montana dams on the Madison and Missouri rivers (FERC Project 2188).

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.

In 2007, the WCTA was updated and combined with a similar document for Yellowstone Cutthroat Trout *Oncorhynchus clarki bouvieri* (Montana FWP 2007).

Signatories to the 2007 Montana Cutthroat Trout Agreement are American Wildlands, the Blackfeet Tribal Business Council, the Confederated Salish and Kootenai Tribes, the Federation of Fly Fishers, the Greater Yellowstone Coalition, the Montana Chapter of the American Fisheries Society, the Montana Cutthroat Trout Technical Committee, the Montana Department of Environmental Quality, the Montana Department of Natural Resources and Conservation, the Montana Farm Bureau, Montana Fish, Wildlife & Parks, the Montana Stockgrowers Association, Montana Trout Unlimited, the Montana Wildlife Federation, the USDA Natural Resources Conservation Service, the Bureau of Land Management, the U.S. Fish & Wildlife Service, the Forest Service, and Yellowstone National Park. Additionally, Plum Creek Timber Company provided a letter of support for the 2007 Cutthroat Agreement, citing their 30 year agreement with the U.S. Fish & Wildlife Service to the Native Fish Habitat Conservation Plan for Plum Creek properties.

Late in 1996, FWP initiated an 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 FWP 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 WCTA objectives 3, 4, & 5. FWP 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, Clancey 1998b). FWP, 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 initiated in 2003.

In 2001, the Sun Ranch entered into an agreement to assist FWP 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 (Figures 2 & 3) is used to monitor index sites in Ennis Reservoir (Figure 4) for young-of-the-year Arctic grayling *Thymallus arcticus* 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.

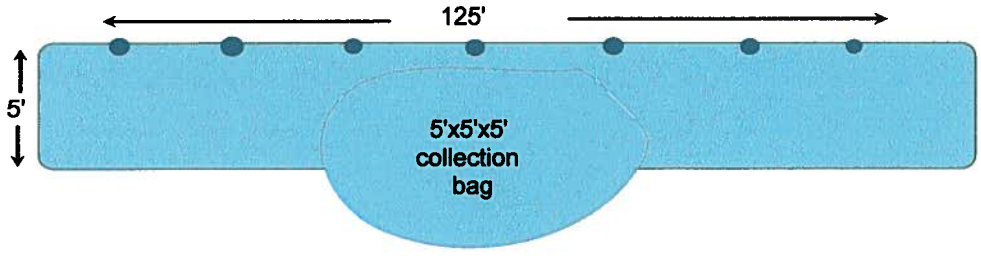


Figure 3. Depiction of a beach seine.

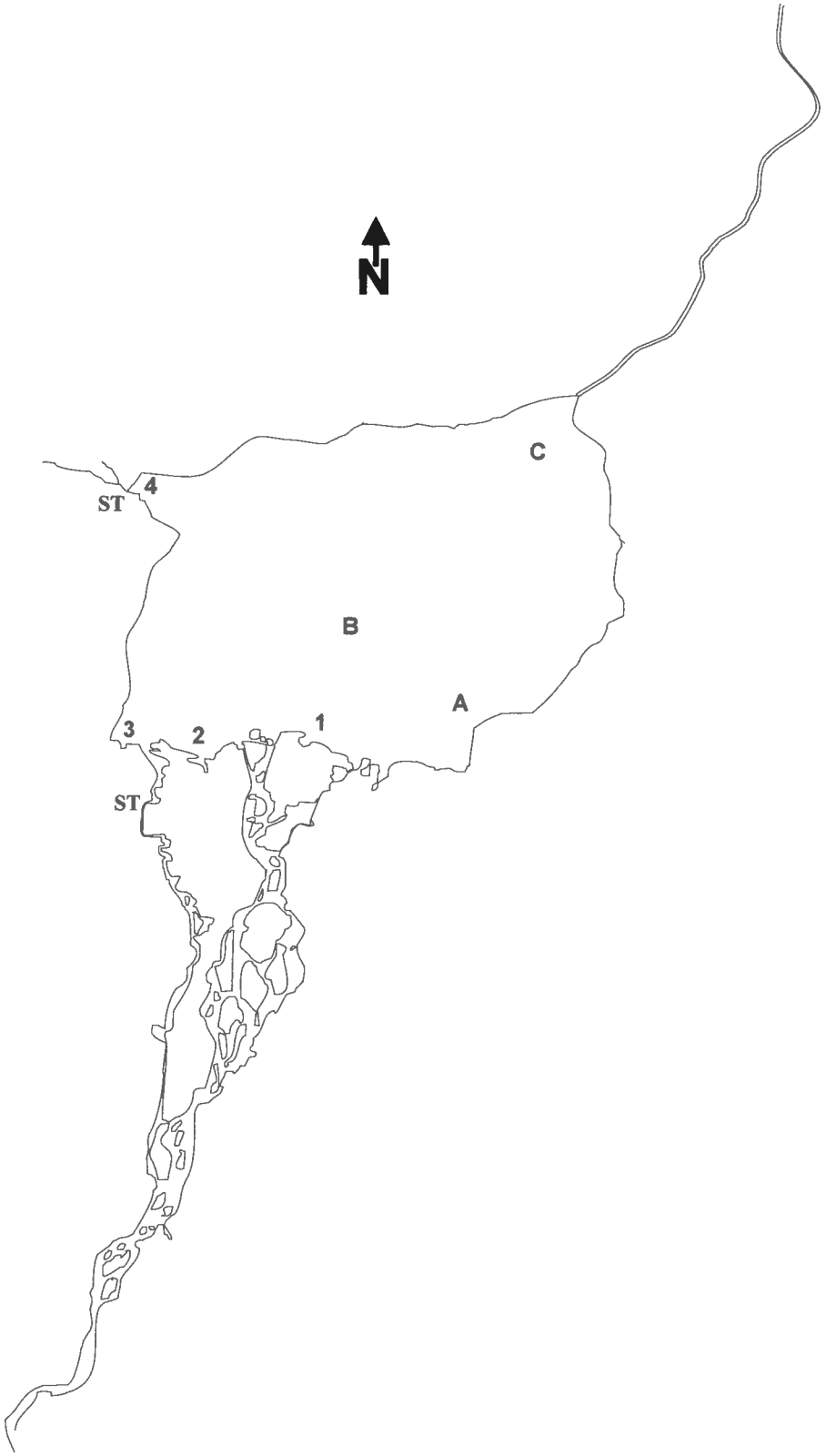


Figure 4. Locations of Ennis Reservoir 2011 beach seining (numbers), gillnetting (letters) and rotary screw trap (ST) sites. The beach seining numbers correspond to locations described in Appendix A.

Rotary screw traps were operated in Fletcher's Channel of the Madison River (Figure 5) and in Meadow Creek, a tributary that enters the northwest corner of Ennis Reservoir, in an effort to sample young-of-the-year Arctic grayling emigration from known or historic spawning sites. Traps were operated from June 6 through July 22 and May 19 to July 8, respectively. The timeline for trap operations was based on previous y-o-y grayling surveys conducted in the Channels section of the Madison River by Jeanes (1996) and MFWP (Byorth and Shepard 1990, Clancey 1995).


Figure 5. Close view of a rotary screw trap, and a rotary screw trap operating in Fletcher's Channel, June 24, 2011. FWP photos by Travis Lohrenz and Pat Clancey.

When operational, the traps fished for no less than a 24-hour period. Fisheries personnel identified fish collected in the trap to species and took measurements of total length in inches. Fish collected at the Meadow Creek trap were given a fin clip and released upstream to calculate trap efficiency and weekly yield estimates.

Plans to deploy a third screw trap in the mainstem Madison River above Ennis Reservoir were abandoned due to the certainty that high Spring runoff would make the trap inaccessible once deployed.

The MadTAC provided $30,000 to Big Hole River Arctic grayling recovery efforts in 2011.

**Population Estimates**

Electrofishing from a driftboat mounted mobile anode system (Figure 6) is the principle method used to capture Madison River trout for population estimates in several sections of the Madison River (Figure 7). Fish captured for population estimates are weighed and measured, marked with a fin clip, and released. A log-likelihood statistical analysis (Montana FWP 2004) is used to estimate trout populations.

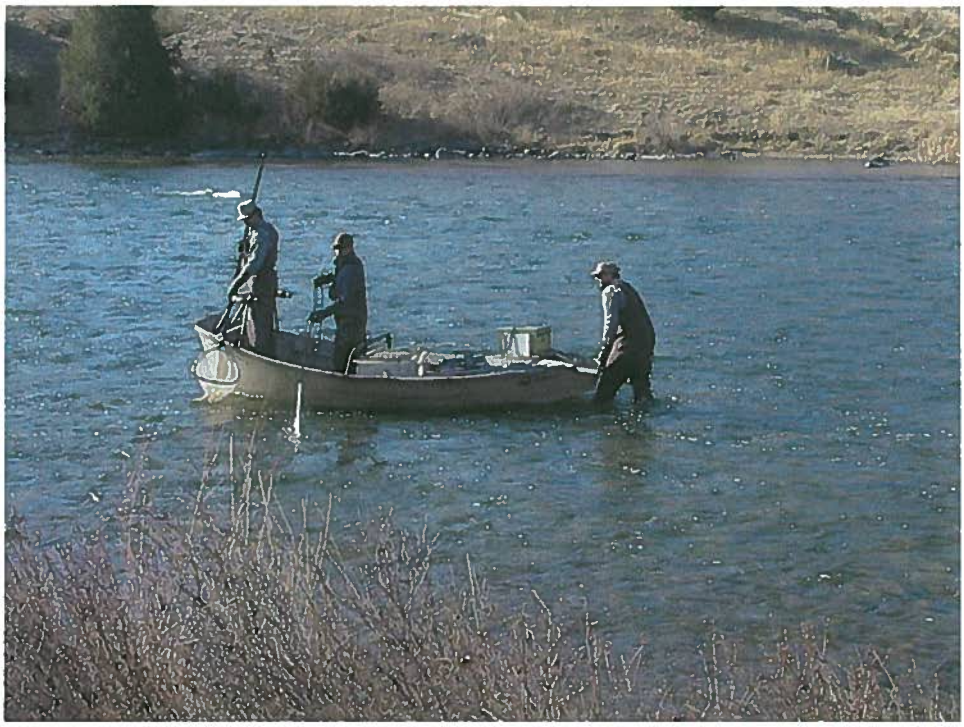

Figure 6. Mobile anode electrofishing (shocking) in the Norris section of the Madison River.

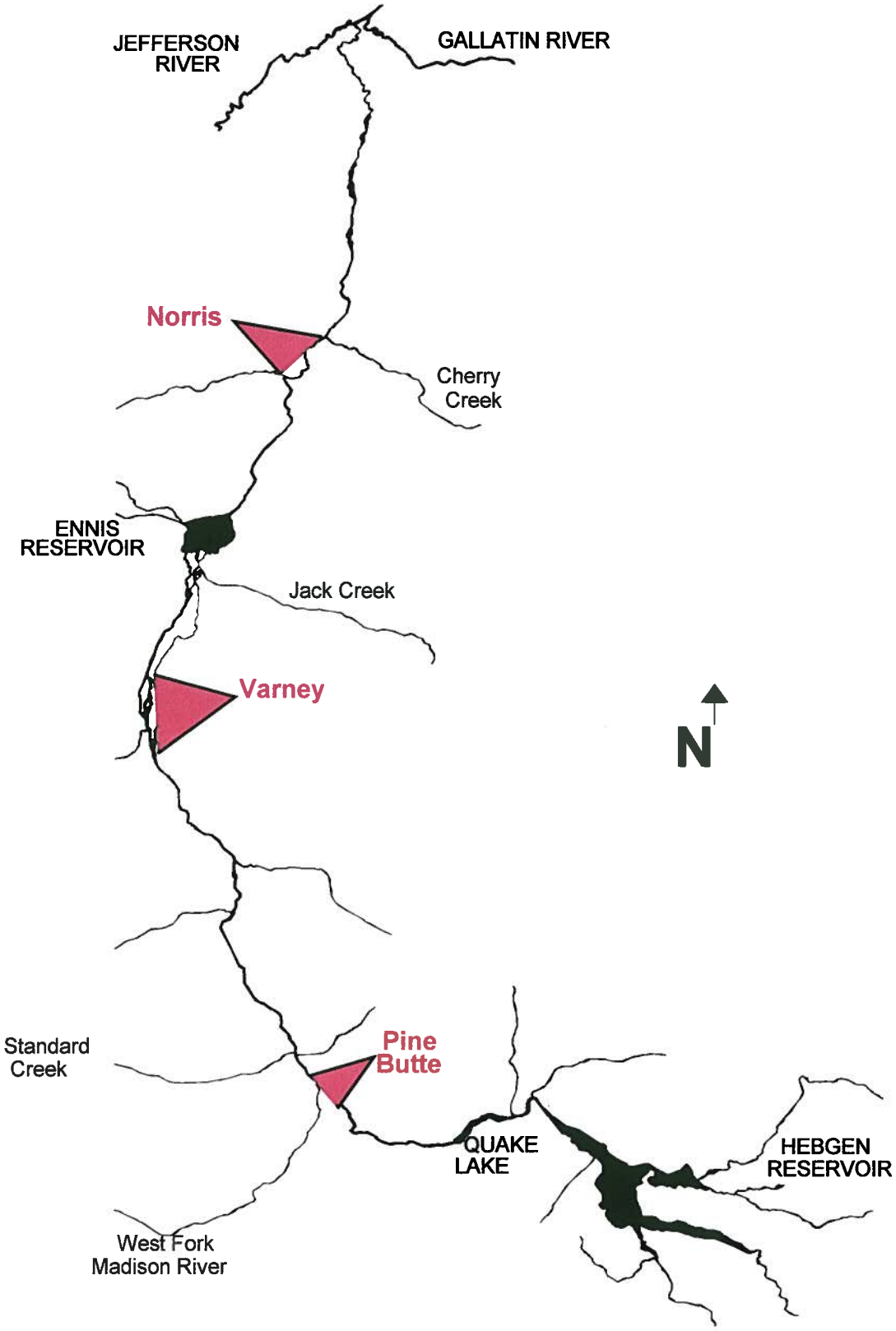


Figure 7. Locations of Montana Fish, Wildlife, & Parks 2011 Madison River population estimate sections.

Aging of Madison fish was ceased in 2000 due to the significant time requirement necessary to continue that activity, though it was continued in the Norris and Pine Butte sections through 2001 and 2003, respectively, to provide information for specific research or management activities.

**Ennis Reservoir Gillnetting**

Gillnetting was conducted in Ennis Reservoir in early October. 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 4). 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.

**Rainbow Trout Radio Telemetry**

In September 2009, 35 Madison River rainbow trout *Oncorhynchus mykiss* were implanted with radio transmitters to compare spawning season movements to a similar study conducted in 1999 (Downing 2000) that included identification of rainbow trout spawning sites in the Madison River upstream of Ennis Reservoir. The transmitters in the current study were on 13 hours each day, with a rated battery life of two years. Transmitters were implanted in fish captured during routine Fall electrofishing in the Pine Butte, Snoball and Varney sections. Additionally, rainbow trout between Burnt Tree and Ennis FAS were captured in Fall 2009 for implantation. Relocations were conducted from a fixed wing aircraft, from a raft, or from roads along the river.

**River Discharge**

*Pulse Flows*

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 a remote temperature monitoring system and a 'pulsed' flow system to mitigate high water temperatures. 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° F or higher and forecast air temperature at Three Forks for the following day is 80° 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 1,100 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 greatest. 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,

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 | ≥ 68°, < 70° | < 80° | ≥ 80° | |
| | | No action | 1400 cfs | |
| Pulsing Required, Volume Contingent of Weather Forecast > 90°F | ≥ 70°, < 72° | < 90° | ≥ 90°, < 95° | ≥ 95° |
| | | 1400 cfs | 1600 cfs | 2100 cfs |
| Pulsing Required, Volume Contingent of Weather Forecast > 85°F | ≥ 72°, < 73° | < 85° | ≥ 85°, < 90° | ≥ 90° |
| | | 1400 cfs | 1600 cfs | 2100 cfs |
| Pulsing Required, Volume Contingent of Weather Forecast > 85°F | ≥ 73° | < 85° | ≥ 85° | |
| | | 1800 cfs | 2400 cfs | |

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.

*Flushing Flows*

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 and organic soil for terrestrial vegetation and other wildlife needs.

*Minimum Flows*

Fish, Wildlife & Parks and PPL Montana (and PPL Montana's predecessor Montana Power Company) have an agreement established in 1968 to maintain minimum instantaneous river flows at the USGS Kirby and McAllister gauges in the upper and lower river of 600 and 1100 cfs, respectively. These instream flow levels were determined by FWP to provide favorable overwinter habitat for yearling trout, and also protect against summer and fall drought in low water years. These minimum flows were incorporated into Article 403 of the FERC license for the 2188 Project and are required elements of operating Hebgen and Ennis dams.

**Temperature Monitoring**

Water temperature was recorded at 15 sites and air temperature at seven sites throughout the Madison River Basin from upstream of Hebgen Reservoir to the mouth of the Madison River at Headwaters State Park (Figure 8). Beginning in 2010, a water temperature recorder was deployed in the river between the Kirby and McAtee sites at a station named 'Wall Creek' to provide data related to the on-going surface discharge out of Hebgen Reservoir during reconstruction of the control structure. Each of the Tidbit™ temperature loggers recorded over 43,000 temperature points in Fahrenheit from late April through early October. Air temperature recorders were placed in areas that were shaded 24 hours per day.

**Aquatic Nuisance Species**

Highway signs announce FWP's West Yellowstone Traveler Information System (TIS) (Figure 9). 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 mud snails in the Madison River and Hebgen Reservoir, and instructs them on methods of reducing the likelihood of transporting New Zealand mud snails 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.

Fish, Wildlife & Parks 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.

In 2010, FWP initiated a public education campaign called "Inspect/Clean/Dry". This campaign uses highway billboards (Figure 10) and vehicle tailgate wraps and posters (Appendix B) to create public awareness of aquatic nuisance species issues.

In September, 2011, the FWP ANS field crews surveyed the Black's Ford, Greycliff and Cobblestone fishing access sites on the Madison River and the Darlinton Ditch foot bridge area at Cobblestone FAS. Water temperature, GPS coordinates, pH, weather conditions, horizontal plankton tow, notes on substrate, and invertebrate and macrophyte surveys were collected. A minimum of 400 feet is surveyed at each site. Horizontal plankton tows were conducted to sample for Zebra and Quagga mussel veligers. Plankton samples were also collected at Varney Bridge, Lyons Bridge and Raynolds Pass fishing access sites and Warm Springs Recreation area. High runoff prevented springtime sampling throughout the drainage.

Vertical pull plankton samples were collected in Hebgen Reservoir near Rainbow Point on two occasions in August, and in September at nine locations throughout the reservoir - Hebgen Dam, Moonlight Bay, Watkins Creek, Lone Tree Horse Butte, South Fork Madison Cabin, the Narrows, Johnson Creek, North Arm, and Madison Arm Marina.
Plankton samples were collected in Ennis Reservoir in August or early September at Kobayashi Beach, Clute's Landing and at the North End.

In addition to regular biological monitoring, angler/boater surveys were conducted on the to inspect watercraft and angling gear for AIS and to educate the public on AIS issues. In 2011, check stations were located at Ennis Reservoir launch sites at Clute's Landing and Kobayashi Beach. Twenty-five boats were inspected, mostly from Montana (1 from Nevada and 1 from Michigan – both states positive for high risk aquatic invasive species). Most water users moved only within Montana, but there were occurrences of use in Colorado and Idaho as well. The majority of boaters had clean watercraft and were aware of AIS issues and none of the angling boats were using live bait.

Inspection stations were also held on the Madison River on two occasions at Lyons Bridge and Warm Springs FAS. Fifty-nine boats were inspected, mostly from Montana, but also from Idaho, Colorado, Wyoming, Florida, Missouri, Nevada, New York and Oregon. Only one of the water users was a recreationist, the remainder were guides and/or anglers. Most were well aware of AIS and frequently clean their boat and gear. Again, none were using live bait.

In 2009 the FWP ANS program conducted monitoring of dissolved calcium concentration in state waters to evaluate risk of zebra and quagga mussel establishment. The calcium level of a water body is a critical characteristic for zebra and quagga mussel establishment. These mussel species do not survive when there is a low calcium concentration in the water, since calcium is an essential element in the composition of the bivalve shell. Calcium concentrations of 15 mg/liter or less are thought to limit the distribution of zebra and quagga mussels. Survival of the larvae and size of an established adult population are both thought to increase with increasing levels of calcium.

New Zealand Mud Snails

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

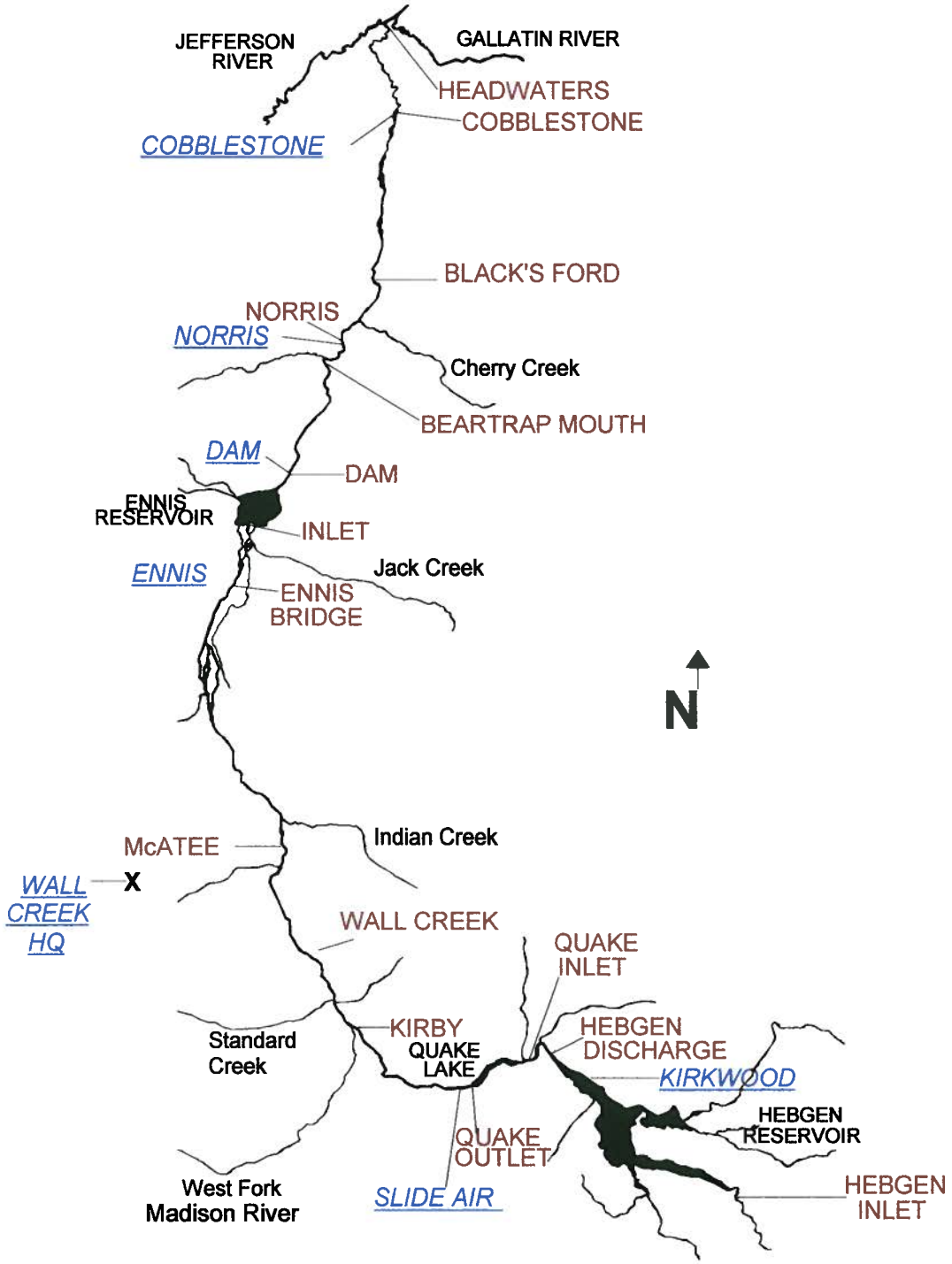


Figure 8. Locations of Montana Fish, Wildlife & Parks temperature monitoring sites. Air temperature monitoring sites are blue; water temperature monitoring sites are red. A river site near Wall Creek was added in 2010.


Figure 9. Roadside sign announcing the Traveler Information System near West Yellowstone, Montana.


Figure 10. Inspect/Clean/Dry billboard.

Whirling Disease

Whirling disease monitoring was not conducted in the Madison River in 2011. From 1996 – 2010 sentinel cage techniques were used to monitor the infection rate and severity of rainbow trout to whirling disease. Each cage would hold 60 young-of-the-year rainbow trout for 10 days. At the end of the 10 day period, fish were transferred to whirling disease free water in a laboratory where they were held until they are 90 days old, at which time they were euthanized and sent to the

Washington Animal Disease Diagnostic Lab (WADDL) for analyses. Juvenile rainbow trout used in the studies were not offspring of Madison River fish, but were from the same captive stock used since studies began in 1996. This stock was used continuously over the years to allow comparison over time and among 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.

**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 (Clancey 1998a, Sloat et al. 2000). Backpack electrofishing was used to survey fish species. Removal of non-native species will typically require use of the EPA registered piscicides (fish-pesticides) rotenone or antimycin.

The Madison District of the U.S. Forest Service and Yellowstone National Park are conducting projects to benefit westslope cutthroat trout and/or to restore stream habitat in tributaries to the Madison River. Grant money from the PPL Montana relicensing agreement was granted to each of those federal agencies to assist their efforts.

Sun Ranch Westslope Cutthroat Trout Brood

Gametes (eggs & milt) for the Sun Ranch Westslope Cutthroat Trout program were collected from three streams and the Sun Ranch brood stock in 2011. All fertilized eggs were transported to the Sun Ranch Hatchery for incubation and hatching (Figure 11). A portion of the resulting fry from one stream and the Sun brood were introduced to the Sun Ranch Brood Pond (Figure 12) 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 maintain the Sun Ranch brood.

Occasionally, when project personnel are unavailable to do so, USFWS personnel from the Ennis National Fish Hatchery care-take 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 waterfall (Figure 13) approximately 8 miles upstream of the Madison River confluence. The only fish species present

Figure 11. Sun Ranch Hatchery rearing troughs.

Figure 12. Sun Ranch Brood Pond.

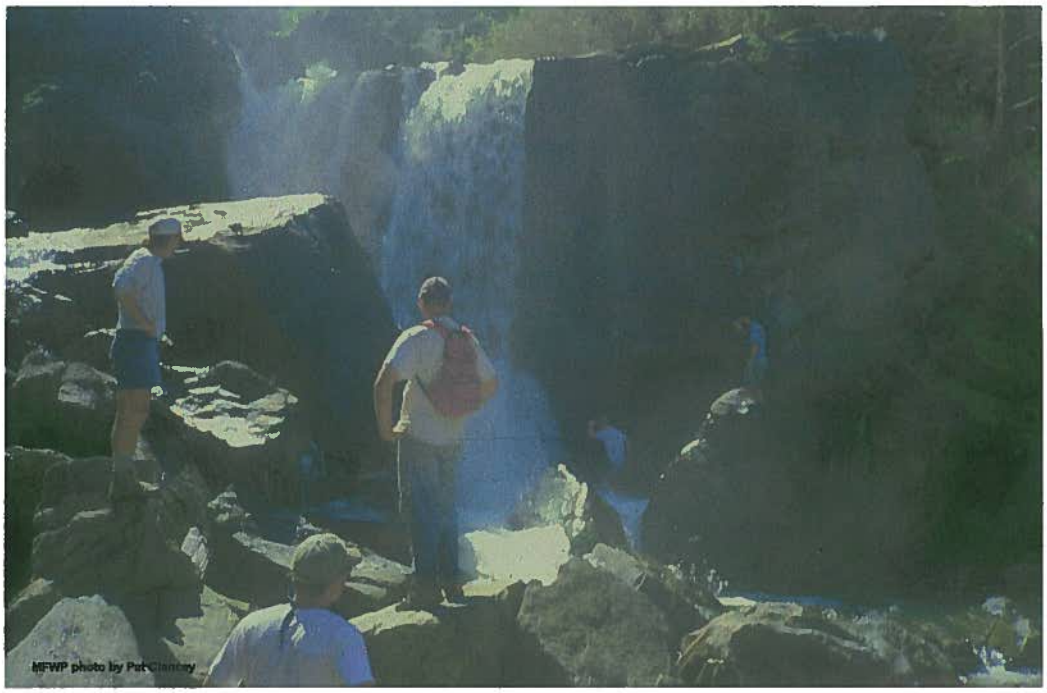


Figure 13. Cherry Creek waterfall located at stream mile 8.0. This falls is the downstream extent of the Cherry Creek project area.

in the project area in 2003 were brook trout *Salvelinus fontinalis*, rainbow trout, and Yellowstone cutthroat trout *Oncorhynchus clarki bouvieri* (YCT; Figure 14). The large size of the project area required that the project be completed in phases. Each phase was treated with fish toxicants for at least two consecutive years. Chemical treatments to eradicate non-native fish were completed in 2010, and westslope cutthroat trout introductions continued in 2011.

In 2011, young-of-the-year westslope cutthroat from the Sun Ranch brood were stocked into Phase 4 of the project area, and young-of-the-year westslope cutthroat from a wild stream population were stocked into Cherry Lake. From 2006 – 2010, westslope cutthroat trout eyed eggs from wild donor populations, the Sun Ranch brood, and the Washoe Park Hatchery were placed in a remote streamside incubator (RSI; Figure 15), hatched, and fry swam out of the RSI into the stream. 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.

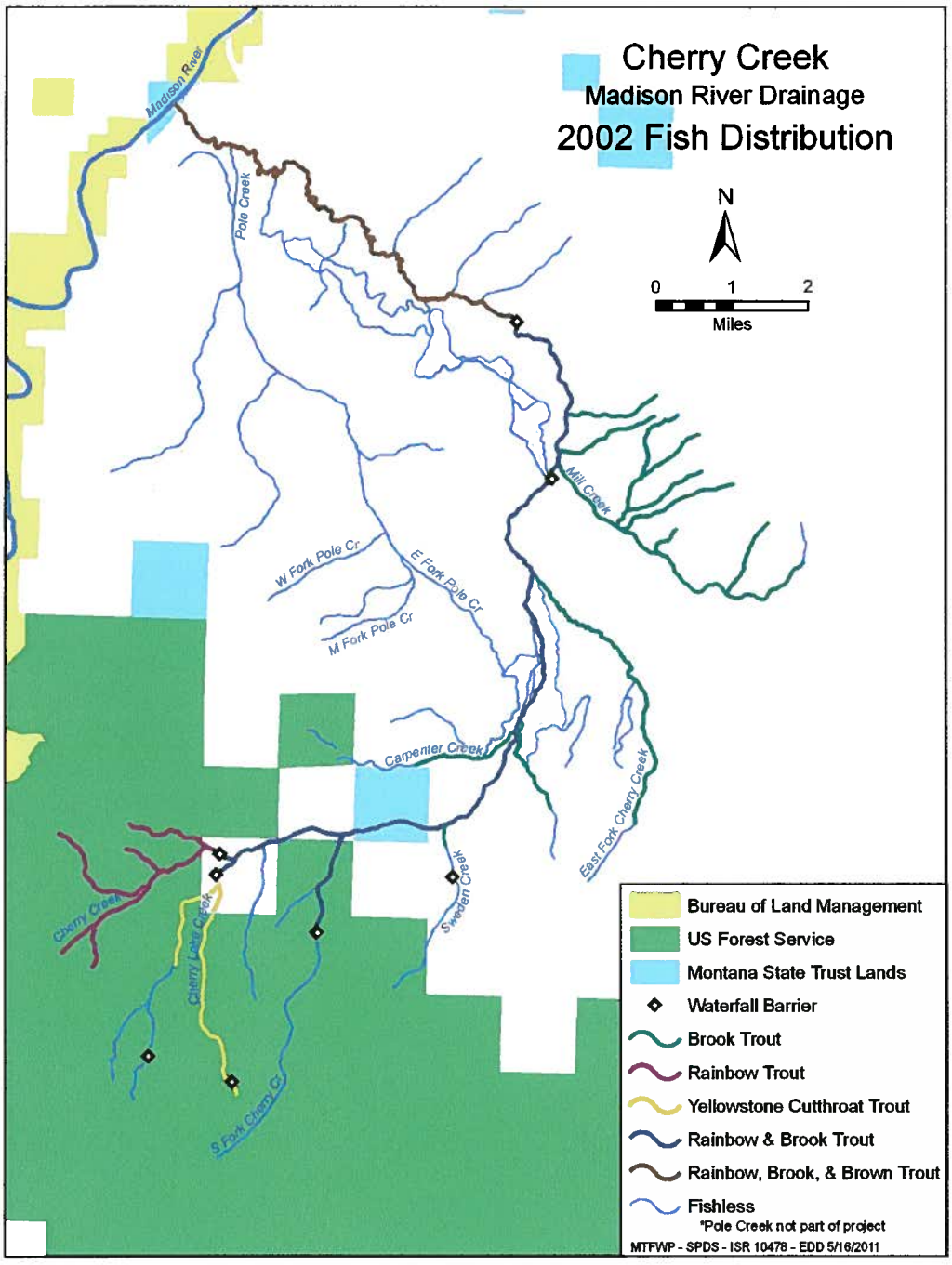


Figure 14. Map of the Cherry Creek Drainage showing the 2002 non-native fish distribution.

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

**Fish Habitat Enhancement**

Smith Lake

Smith Lake Dam on Lake Creek, a tributary to the West Fork of the Madison River, is a four foot high cobble and earthen dam believed to have been constructed in the 1920s. The purpose of the structure was to divert water for operation of a sluice box and water wheel pump to pump water 500 vertical feet to an offsite livestock water trough. Brown trout *Salmo trutta* migrate up Lake Creek for spawning, but in some years, fish passage around the dam was blocked by tarps that were used to reduce leakage through the dam and the bypass channel. Several alternative methods were explored to provide stockwater and reduce or eliminate the need for the water wheel pump. In 2009, MFWP, the Madison River Foundation (www.madisonriverfoundation.org) and the Madison District of the Beaverhead-Deerlodge National Forest developed a well and pipeline system to supply livestock water, eliminating the need to operate the flume at Smith Lake Dam, and thus the need to place tarps on the dam that created a barrier to upstream migrating brown trout from the Madison River.

Jack Creek

Jack Creek is a tributary to the Madison River approximately two miles upstream of Ennis Reservoir. The MadTAC has contributed funding for habitat enhancement projects on Jack Creek and one of its tributaries, McKee Spring Creek. FWP established two fish monitoring sections on Jack Creek to evaluate the effects of the habitat improvements. The Madison Valley Ranch section serves as a control where no habitat improvement is occurring. In Fall 2010 the Jack Creek Ranch

section was converted from a straightened and channelized section to a sinuous channel with pools, point bars, and other fish habitat improvements. Electrofishing was conducted in April 2008 and April 2010 to establish a pre-project fisheries baseline for comparison with the post project fish population. Post-project fisheries monitoring was initiated in April 2011.

South Fork of Meadow Creek

A project to replace an aged irrigation system in a section of the South Fork of Meadow Creek was initiated in 2011. Upon completion the project will include reconstruction of instream irrigation weirs, headgates, and irrigation water delivery systems to improve efficiency. The new instream diversions will be designed and constructed to facilitate fish movement through them, and water delivery will be via pipeline rather than open ditch. Approximately 3,000 feet of stream will be fenced as part of the project to prevent livestock encroachment within 30 feet on either side of the stream. Funding for the project is from the Montana Department of Natural Resources and Conservation, Montana Department of Environmental Quality, Madison Conservation District, PPL Montana Madison Fisheries Technical Advisory Committee, and the landowners.

**Hebgen Basin**

Hebgen Reservoir and its tributaries are shown in Figure 16.

Hebgen Reservoir Gillnetting

Gillnetting has been conducted annually on Hebgen Reservoir by FWP for over thirty years to monitor trends in reservoir fish populations, including species assemblage, age structure, and the contribution of hatchery reared rainbow trout to the Hebgen fishery.

Variable mesh 125 foot long experimental gillnets were deployed overnight at index sites on Hebgen Reservoir (Figure 17) over a three-day period during the new moon phase in late May or early June. Twenty-five nets (14 floating and 11 sinking nets) were fished during this period, with a maximum of nine nets fished per night.

Samples were sorted by net and processed systematically by species with total length and weight recorded. Rainbow trout were also visually examined for physical anomalies seen in hatchery-reared stocks, and for external and internal tags applied to wild juvenile and adult rainbow trout at tributary traps in previous years. Vertebrae were extracted from rainbow trout specimens and examined for the presence of tetracycline marks, a biological stain that appears in ossified structures. Tetracycline can be added to hatchery pellets to put a mark in the vertebrae, creating a positive identification feature for hatchery raised fish.

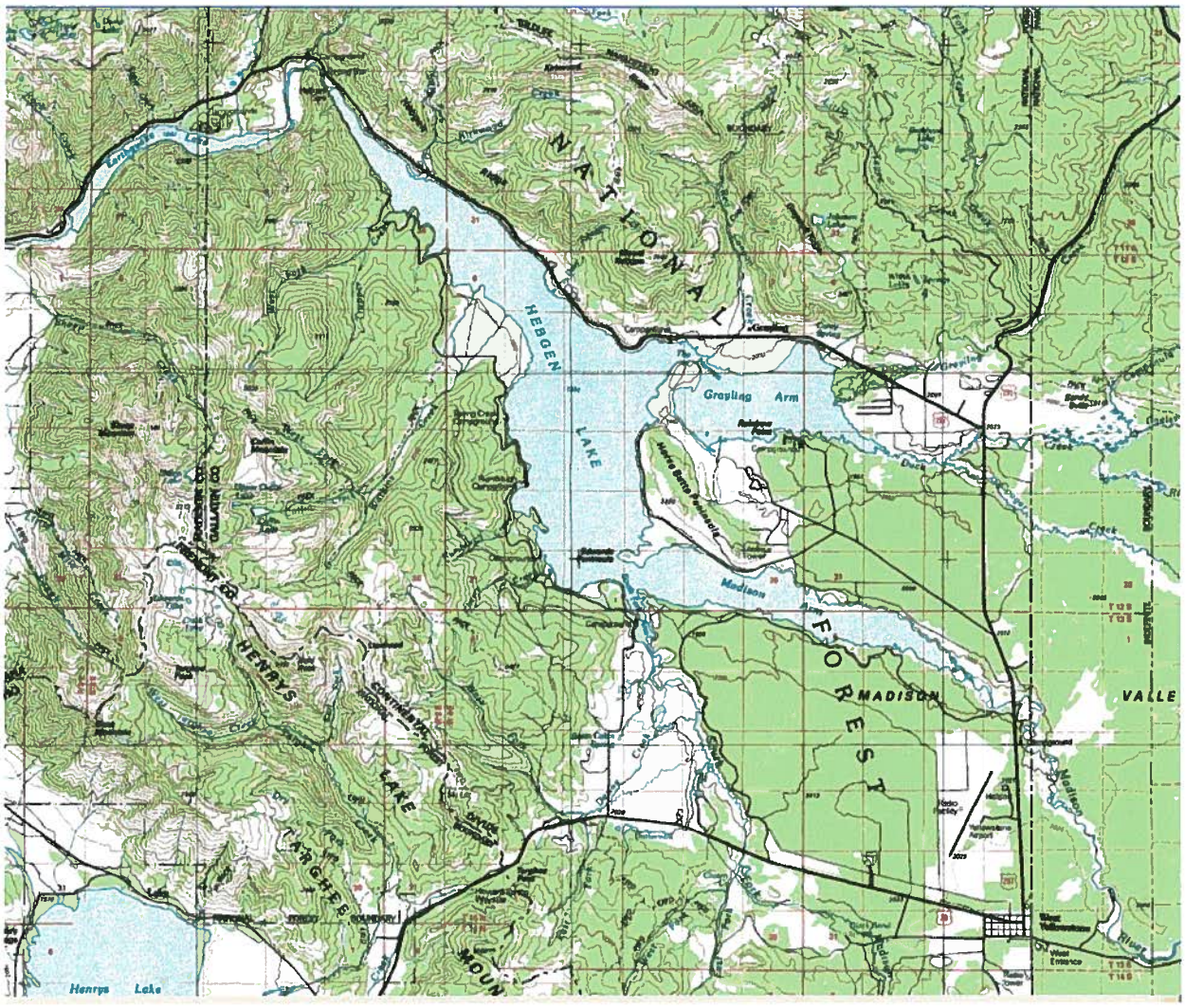


Figure 16. Map of Hebgen Reservoir and surrounding area.

## Hebgen Reservoir Tributary Habitat Improvement Monitoring

*South Fork Madison Large Woody Debris Project*

FWP personnel conducted fish population monitoring for changes in fish assemblages and abundance in Phase I of a large woody debris habitat enhancement project implemented in 2006 by the Gallatin National Forest. Monitoring was conducted using mobile anode electrofishing equipment. Fish captured were identified to species, enumerated and measured for total length.

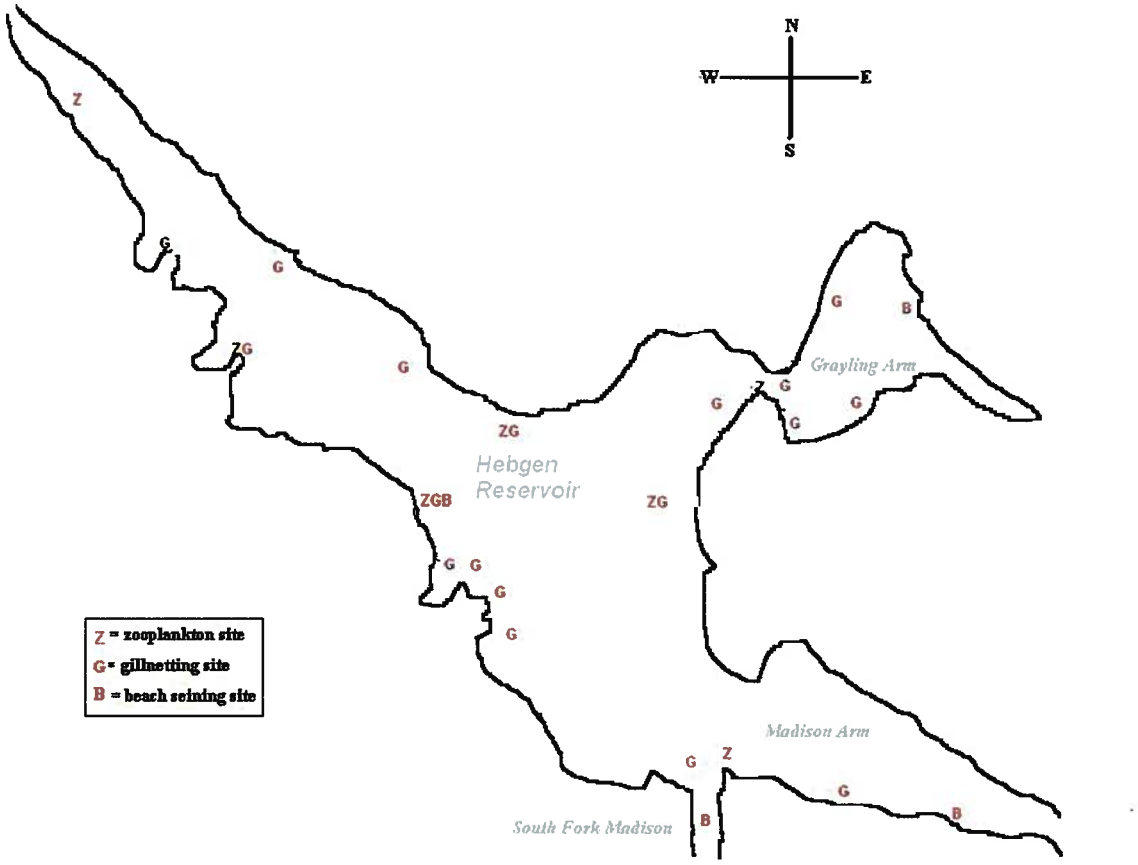


Figure 17. Map showing monitoring site locations of Hebgen Reservoir zooplankton, gillnetting, and beach seining.

*Watkins Creek Large Woody Debris Project*

Watkins Creek is a tributary to Hebgen Reservoir's west side. Use of Watkins Creek for spawning by reservoir rainbow trout has been limited. In 2010, in an effort to increase the quantity and quality of spawning habitat and recruitment of rainbow trout to Hebgen, the Gallatin National Forest conducted a project to add large woody debris to a quarter mile section of Watkins Creek to promote the trapping and sorting of spawning gravels (Appendix C). FWP 2188 project personnel are monitoring the fish population response to the project. Three fisheries monitoring sites were established – one within the project reach and control reaches upstream and downstream to evaluate the effectiveness of the habitat enhancement project on fish assemblage, relative abundance and spawning use by Hebgen rainbow trout. Monitoring within the reaches was conducted with a Smith-Root backpack electrofisher model 12-B POW. Fish captured were enumerated by species and measured for total length. Additionally, total

electrofishing time for each section was used to calculate a catch per unit effort (CPUE) estimate index of abundance..

## Hebgen Basin Whirling Disease Monitoring

Whirling disease monitoring was not conducted in any Hebgen Reservoir tributaries in 2011.

## Hebgen Basin Juvenile Fish Sampling

Rotary screw traps were not deployed in any Hebgen Reservoir tributaries in 2011.

## Hebgen Basin Tributary Spawner Trapping

Hebgen tributaries were not trapped for spawning adults in 2011.

## Hebgen Reservoir Shoreline Juvenile Fish Sampling

Beach seining was conducted at several sites on Hebgen Reservoir to monitor overlap of juvenile habitat use among young-of-the-year rainbow trout, brown trout, mountain whitefish, and Utah chub. Samples were collected using a 125'x 5' x ¼" inch mesh seine with a 5'x 5' x 5' collection bag (Figure 3). The float and lead lines of the seine are tied to long dowels and pulled through the water by two people (Figure 2) for approximately 100 yards, then pulled onto shore where fish are separated from debris and enumerated. At each site all young-of-the-year trout, whitefish, and up to 30 Utah chub are measured. All remaining chubs are enumerated.

## Hebgen Reservoir Zooplankton Monitoring

Monthly zooplankton tows were conducted at seven established sites on Hebgen Reservoir to evaluate plankton community densities and composition (Figure 17). Plankton were collected with a Wisconsin plankton net (Figure 18) with 153 micron mesh (1 micron = 1/1,000,000$^{th}$ meter) towed vertically through the entire water column at one meter per second. Tows were taken at locations with a minimum depth of 10 meters. Samples were rinsed and preserved in a 95% ethyl alcohol solution for enumeration.

Zooplankton were identified to order Cladocera (daphnia) or Eucopepoda (copepods), and densities from each sample were calculated. Carapace length was measured on six individuals of each Cladocera and Eucopopoda from each aliquot. Length adjustments were made to convert from micrometers to millimeters, and individual lengths were recorded in millimeters. Mean length was calculated for each sample and each site to determine if spatial and temporal variation existed.

A Secchi disk (Figure 18) was used to measure light penetration (in meters) into the Hebgen Reservoir water column. Depths were taken in conjunction with zooplankton tows to establish a Trophic State Index number (TSI) to determine reservoir productivity (Carlson 1977). Secchi depths were recorded as the distance from the water surface to the point in the water column where the disk colors became indiscernible.

Figure 18. A Wisconsin plankton net (left) and Secchi disk (right) used to collect zooplankton and measure light penetration, respectively, in Hebgen Reservoir.

## RESULTS AND DISCUSSION

### Madison Grayling

No young-of-the-year Arctic grayling were captured during beach seining in Ennis Reservoir in 2011 (Appendix A) or in screw traps in Fletcher's Channel and Meadow Creek.

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 creates similar conditions. The duration and severity of the Madison River ice gorge (Figure 19) may affect the spawning success of the Ennis Reservoir grayling.

In April 2007, the USFWS determined that fluvial Arctic grayling in the Big Hole River did not qualify as a Distinct Population Segment (DPS), and therefore were not warranted for listing as a Threatened species under the Endangered Species Act (ESA). This decision was challenged in court. As part of a settlement agreement the USFWS agreed to re-evaluate the status of Arctic grayling in the Missouri River Basin.

In May 2009, the USFWS concluded that all life forms (fluvial and adfluvial) of Arctic grayling in the upper Missouri River Basin were genetically and geographically distinct from other Arctic grayling populations and comprised a significant segment of the global Arctic grayling

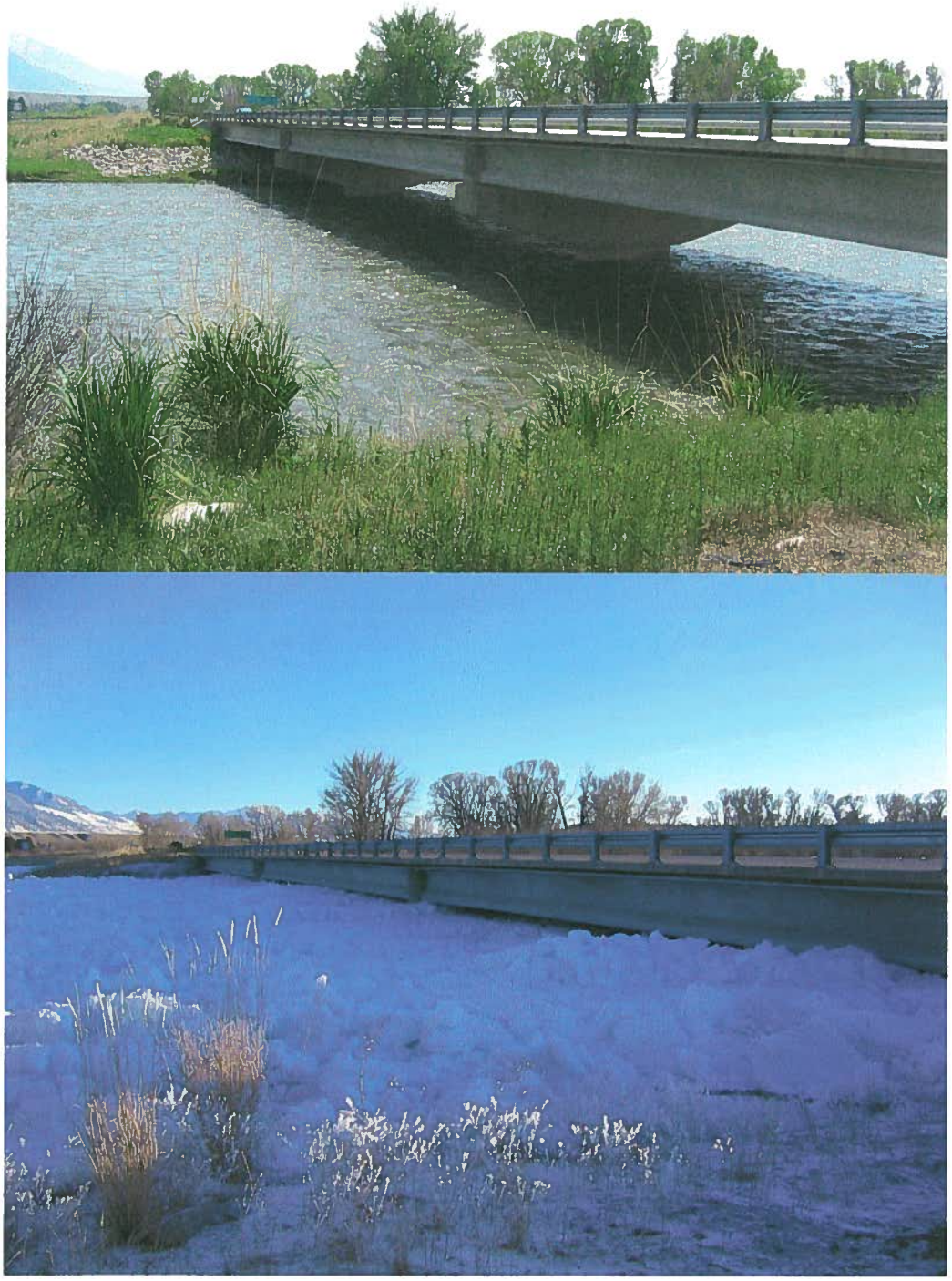

Figure 19. Photos illustrating ice-fee (top) and ice-gorged (bottom) conditions of the Madison River at the U.S. Highway 287 Bridge at Ennis. MFWP photos by Pat Clancey.

population, therefore qualified for designation as a DPS and warranted for listing; however, listing of the Upper Missouri River Arctic grayling DPS under the ESA was precluded due to higher priority species. The Madison River population of Arctic grayling is included in the 2009 DPS designation, therefore may be listed under ESA if the DPS's listing priority is elevated. As part of settlement for a lawsuit associated with many species tenure on the Candidate Species List, the USFWS has agreed to reevaluate the status of Arctic grayling in the Upper Missouri DPS, beginning in October 2013. By September 2014, the USFWS will issue a 12-month finding on the status of Arctic grayling that will either remove Arctic grayling from the Candidate Species List, or introduce a decision through the Federal Register to list Arctic grayling as either Threatened or Endangered.

Madison grayling 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 angler caught grayling in the Madison River as far as 30 miles upstream of Ennis Reservoir into the Fall.

The Fletcher's Channel screw trap operated sporadically due to a high and prolonged spring runoff in 2011. Flows in the Madison River exceeded 3,000 cfs from June 1 through mid July (Figure 20; USGS provisional data). Optimum drum rotation for trap operation is 5 – 6 revolutions per minute (rpm), with a recommended maximum of 10 rpm's. De-scaling and fish mortality have been observed when drum rotation exceeds 10 rpm. When river discharge exceeded 4,000 cfs de-scaling and mortality of captured fish was observed. Additionally, crew safety became a concern with high flows and the large amount debris that accumulated at the trap.

The Fletcher's trap operation yielded no arctic grayling and low numbers of other fish (Table 2), likely due at least in part to the operational constraints dictated by runoff. Jeanes (1996) found young-of-the-year grayling emigrate in June from rearing areas in the Channels section to Ennis Reservoir. Due to high discharge, the Fletchers channel screw trap was operational for only 10 days during June.

Montana FWP personnel identified a Fathead minnow *Pimephales promelas* captured during trap operation. The Fathead minnow is native to Montana waters in the eastern half of the state, but have been dispersed in other locations likely due to bait bucket releases. Until now the southernmost point of their known distribution in the Missouri River drainage was in the Three Forks Ponds (Holton and Johnson 2003).

No grayling were captured in the Meadow Creek screw trap (Table 3). Juvenile brown trout and adult white suckers comprised the majority of the fish sampled. Trap efficiency for brown trout was 10% with a yield estimate of 393 brown trout /week. Peak emigration of brown trout increased with stream discharge from May 26 to June 8 (Figure 21). No efficiency or weekly yield estimates for juvenile rainbow trout were calculated because no recaptures were recovered.

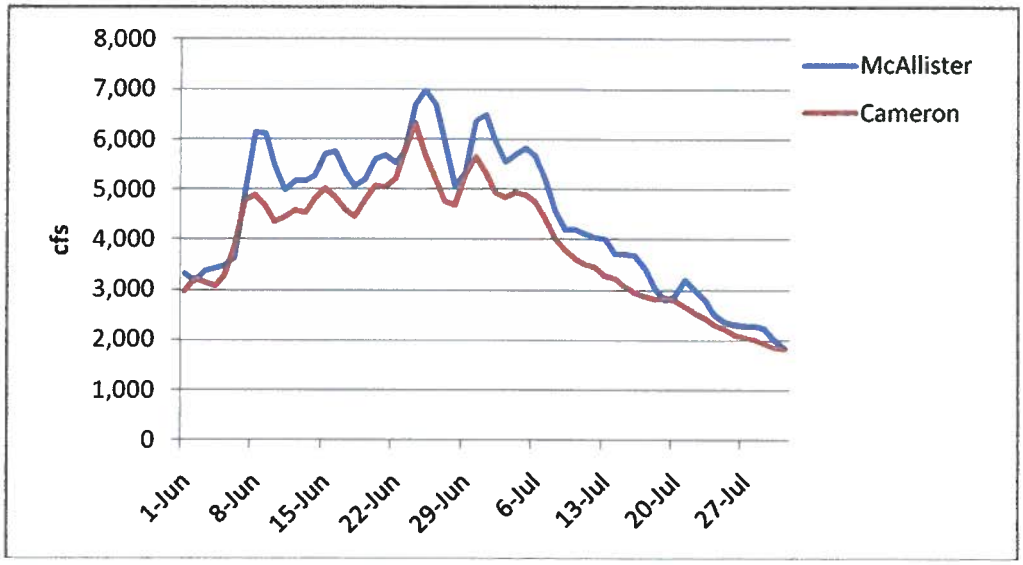


Figure 20. Daily discharge of the Madison River at USGS Varney and McAllister gauges during Fletcher's channel rotary screw trap operation, June 6 – July 22, based on provisional USGS data.

Table 2. Catch of rotary screw trap in Fletcher's Channel, Madison River, June 6 – July 22, 2011.

| | Number Sampled | Mean Length (min – max) |
|---|---|---|
| Rainbow Trout | 28 | 2.2 (1.3-6.1) |
| Rainbow Trout Y-O-Y | 12 | |
| Brown Trout | 102 | 2.3 (1.6-8.5) |
| Brown Trout Y-O-Y | 55 | |
| Mountain Whitefish | 8 | 1.7 (1.0-2.7) |
| White Sucker | 11 | 9.5 (3.0-17.6) |
| White Sucker Y-O-Y | 6 | |
| Long-nose Dace | 177 | |
| Mottled Sculpin | 7 | |
| Utah Chub | 6 | 11.9 (10.4-13.7) |

Table 3. Catch of rotary screw trap in Meadow Creek, May 19 - July 8, 2011.

| | Number Sampled | Mean Length (min – max) |
|---|---|---|
| Rainbow Trout | 19 | 4.7 (3.6-6.2) |
| Brown Trout | 493 | 5.0 (2.0-9.4) |
| Brown Trout Y-O-Y | 46 | |
| White sucker | 73 | 15.7 (2.8-21.1) |
| Longnose Dace | 4 | |
| Mottled (Rocky Mountain) Sculpin | 8 | |
| Utah Chub | 13 | 11.8 (8.7-13.9) |

Sexually mature white suckers were collected in the trap from May 20 to June 29. Fisheries personnel administered fin clips to White suckers to estimate the size of the spawning run in Meadow Creek. However, no recaptured white suckers exhibited fin clips so an estimate could not be conducted. White suckers greater than eight inches appeared conditioned to the trap after their initial capture and avoid recapture. Large White suckers were observed swimming around the trap on several occasions, and this behavior was also observed in adult rainbow trout during trap operation on Duck Creek near West Yellowstone in previous years.

MadTAC funds are used to assist with Arctic grayling recovery efforts in the Big Hole, Ruby, and Elk Lake drainages. These funds have helped FWP develop 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 'warranted but precluded', landowners and irrigators continue to enroll in the program. Currently 33 landowners have enrolled 150,481 acres, with an additional 6,542 acres of State land enrolled. Additionally, MadTAC funds have been used to assist with monitoring the development of a self-sustaining Arctic grayling population in the upper Ruby River and developing and implementing stream-flow restoration plan for Narrows Creek, a grayling spawning tributary to Elk Lake.

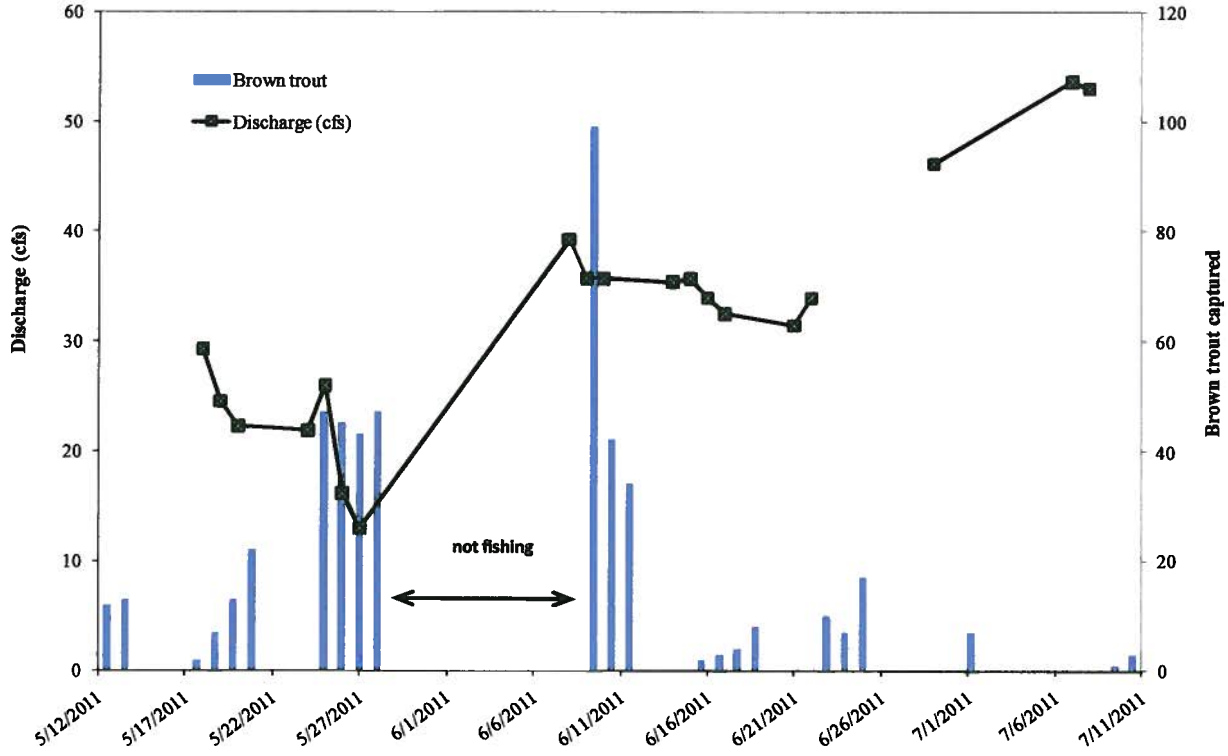


Figure 21. Meadow Creek measured discharge and juvenile brown trout emigration in 2011.

**Population Estimates**

Population estimates were conducted in the Norris section of the Madison River in March and in the Pine Butte and Varney sections in September (Figure 7). A new charting format was adopted in 2011, developed by FWP Regional Fish staff (Vaughn pers comm.). Each chart displays the estimated number of fish 6 inches and larger, and also illustrates additional size groups. The population for each of the size groups displayed includes all larger size groups as well. For instance, the line representing the estimated number of Pine Butte rainbow trout 12 inches and larger (Figure 22) includes all rainbow trout larger than 12 inches, not just those 12 – 14 inches. The size groups depicted on each chart are those for which statistically valid estimates could be derived, so size groups vary by chart.

Figures 22 - 24 illustrate population levels rainbow trout per mile for several size classes in each of the three sections.

Figures 25 - 27 illustrate numbers of six inch and larger brown trout.

Rainbow and brown trout population levels in the Bypass (Figure 28) compare favorably with population levels in other sections of the Madison River (Figures 22-27). The preponderance of holding sites among the boulder and cobble substrate allows for a greater density of fish than

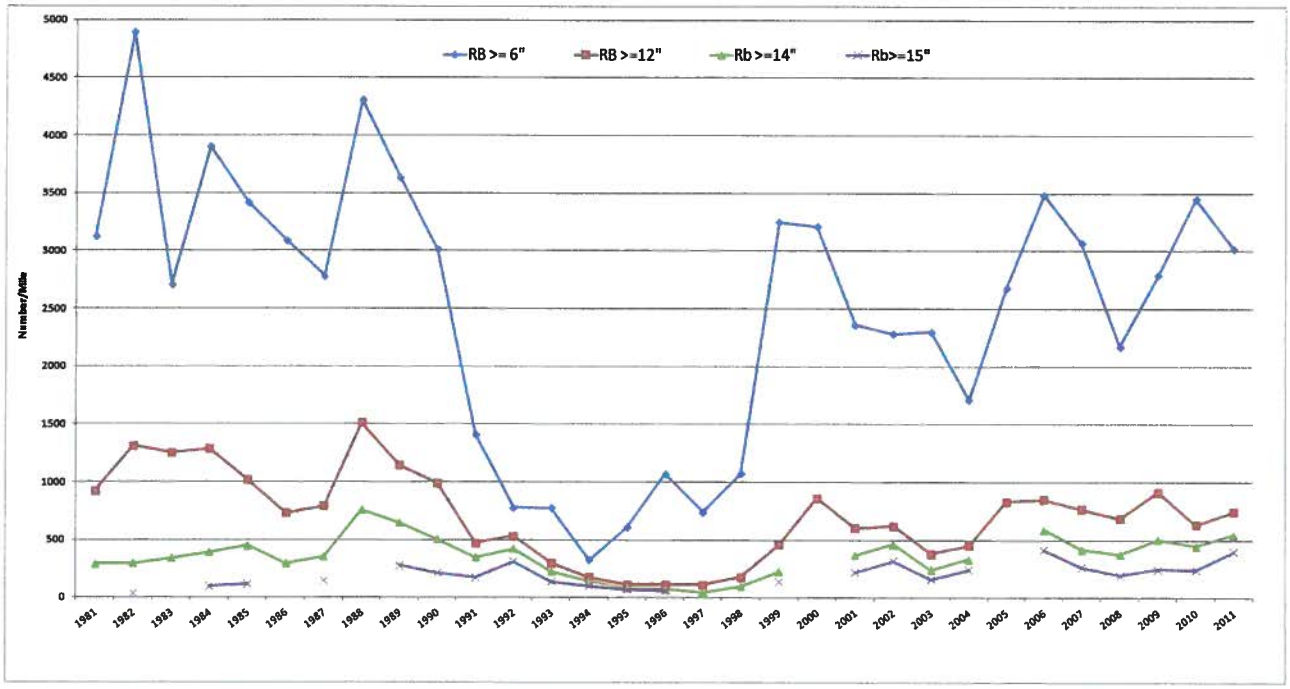


Figure 22. Figure showing the long-term trend of rainbow trout by size group in the Pine Butte section of the Madison River during fall, 1981–2011.

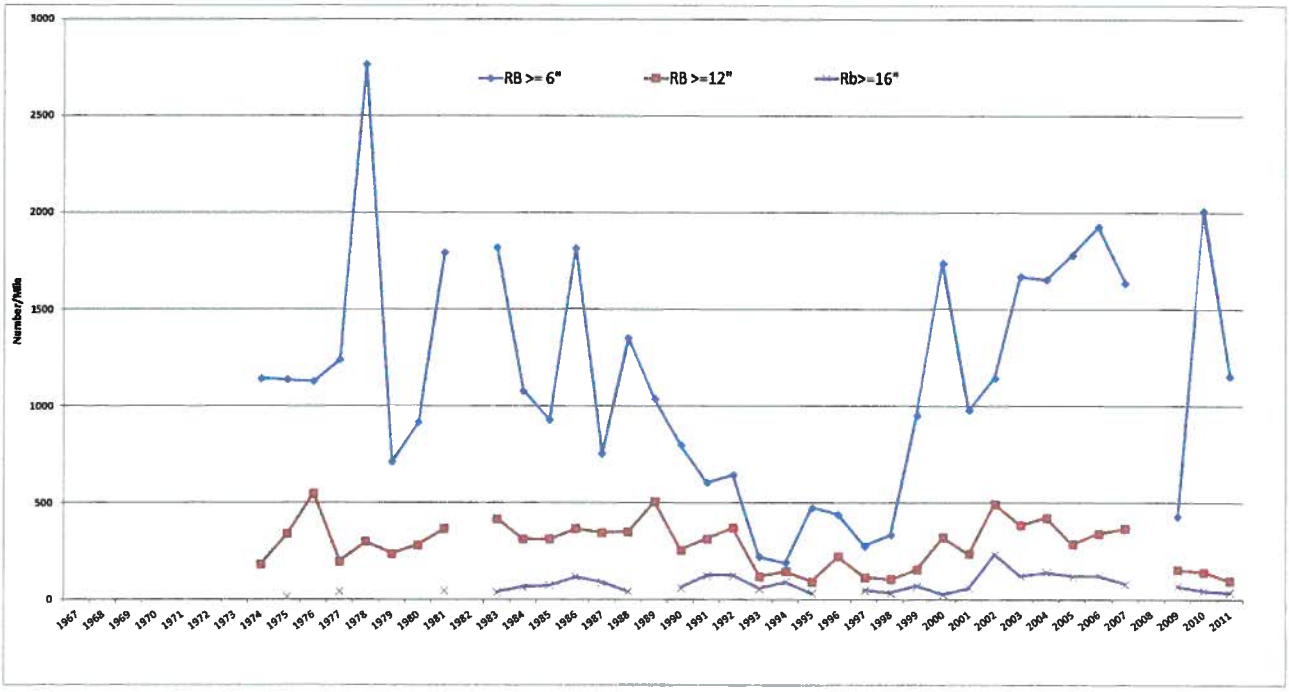


Figure 23. Figure showing the long-term trend of rainbow trout by size group in the Varney section of the Madison River during fall, 1974–2011.

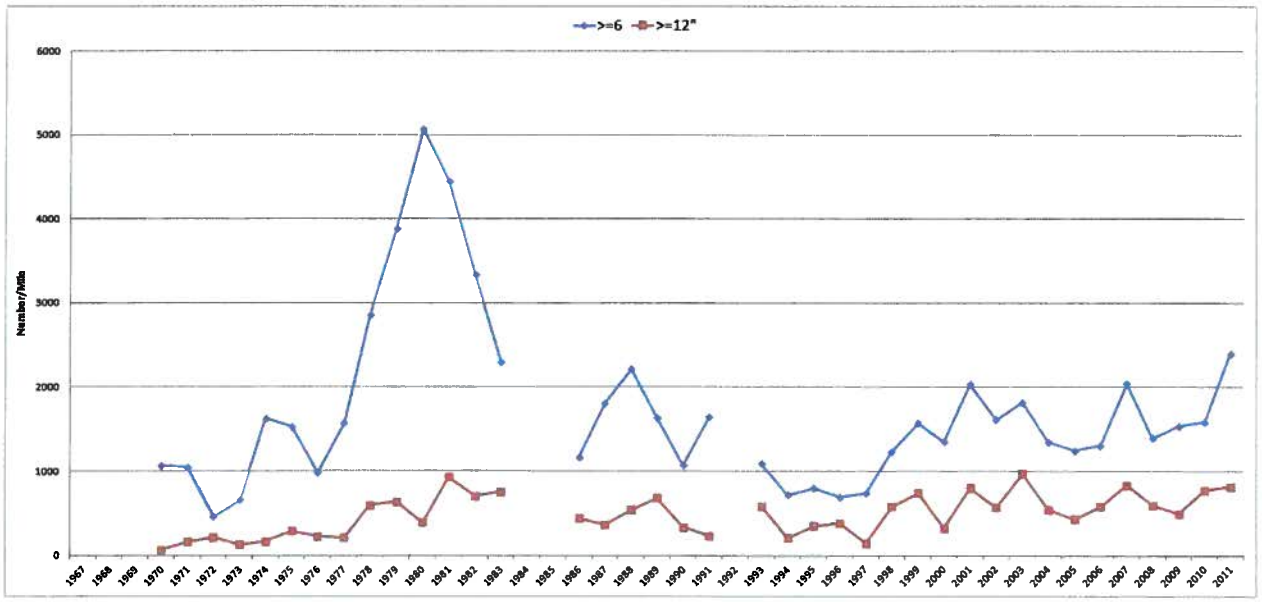


Figure 24. Figure showing the long-term trend of rainbow trout by size group in the Norris section of the Madison River during spring, 1970–2011.

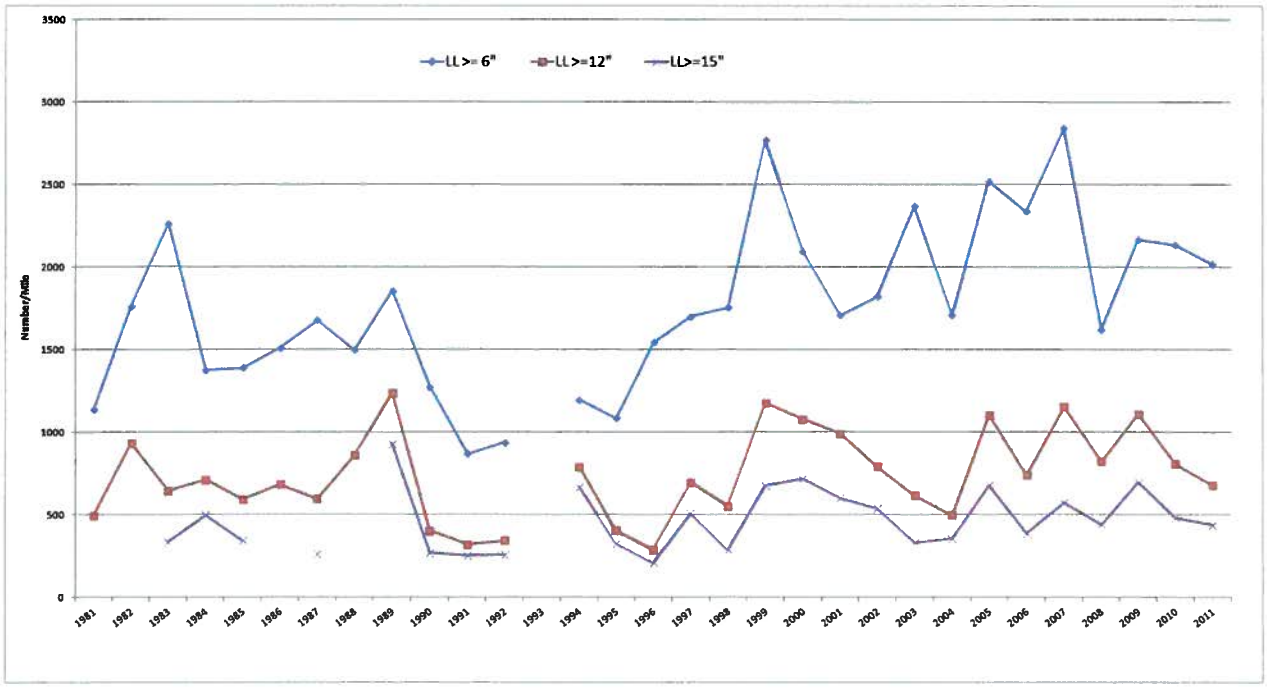


Figure 25. Figure showing the long-term trend of brown trout by size group in the Pine Butte section of the Madison River during fall, 1981–2011.

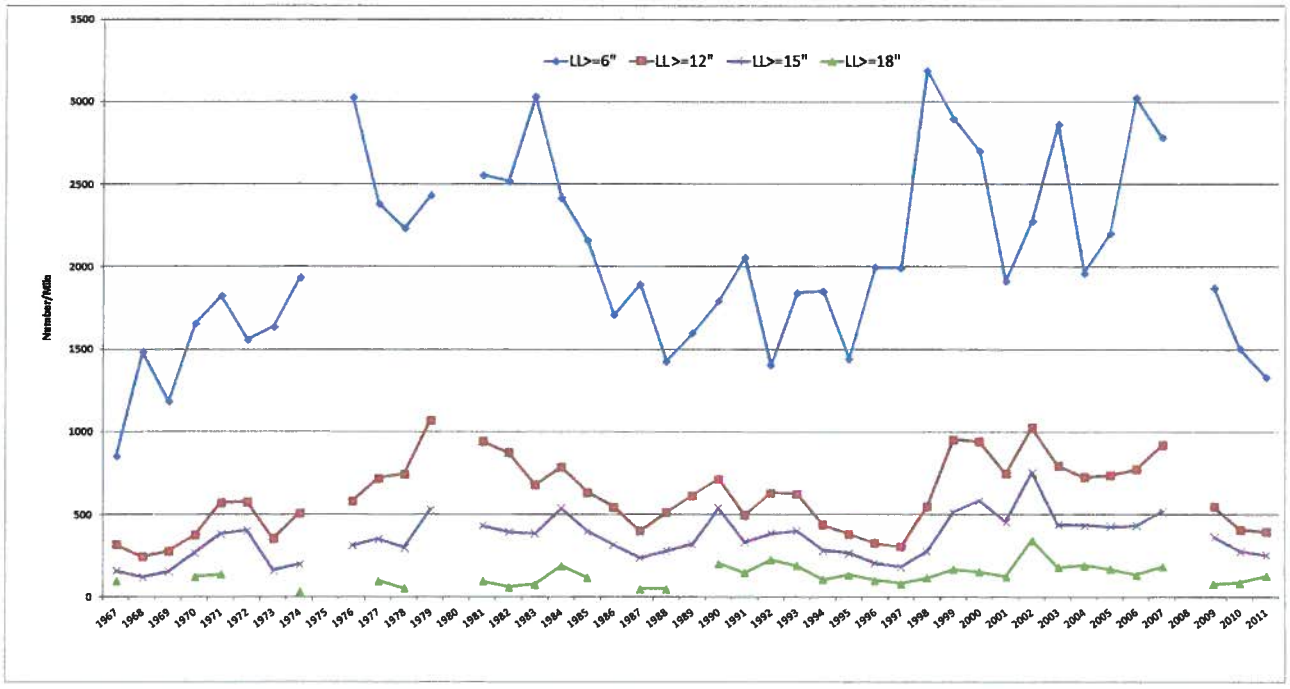


Figure 26. Figure showing the long-term trend of brown trout by size group in the Varney section of the Madison River during fall, 1967–2011.

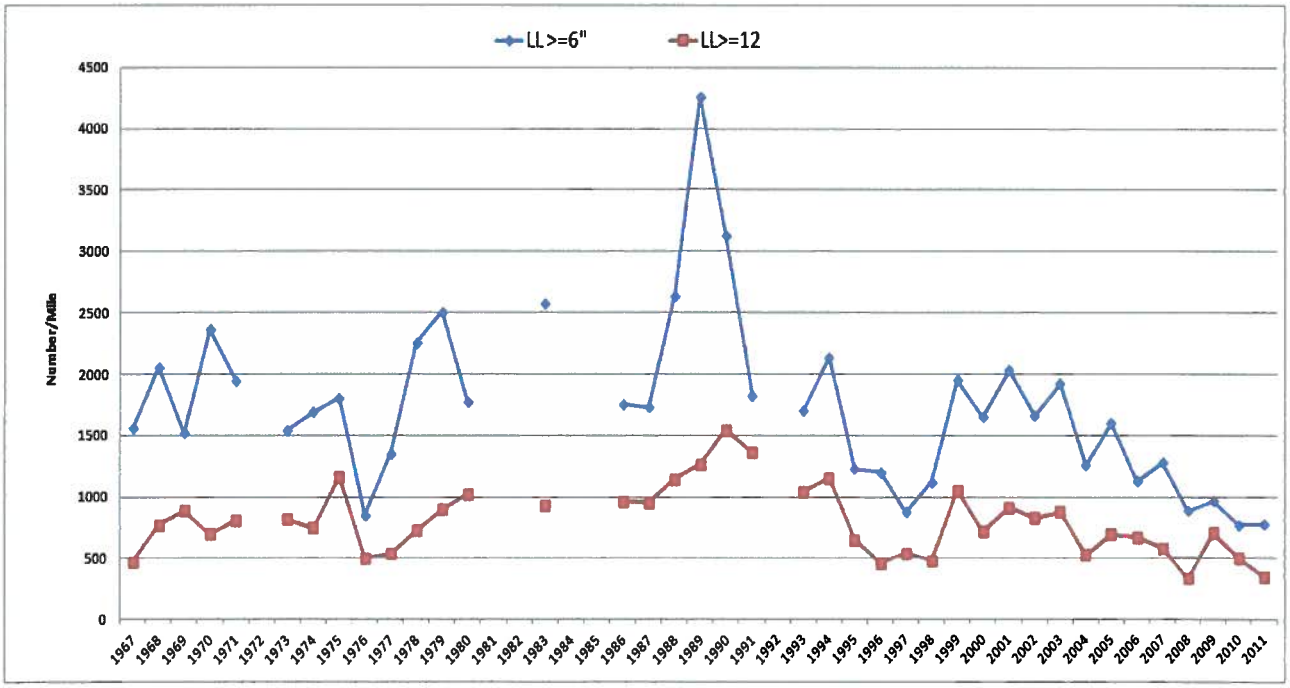


Figure 27. Figure showing long-term trend of brown trout by size group in the Norris section of the Madison River during spring, 1967–2011.

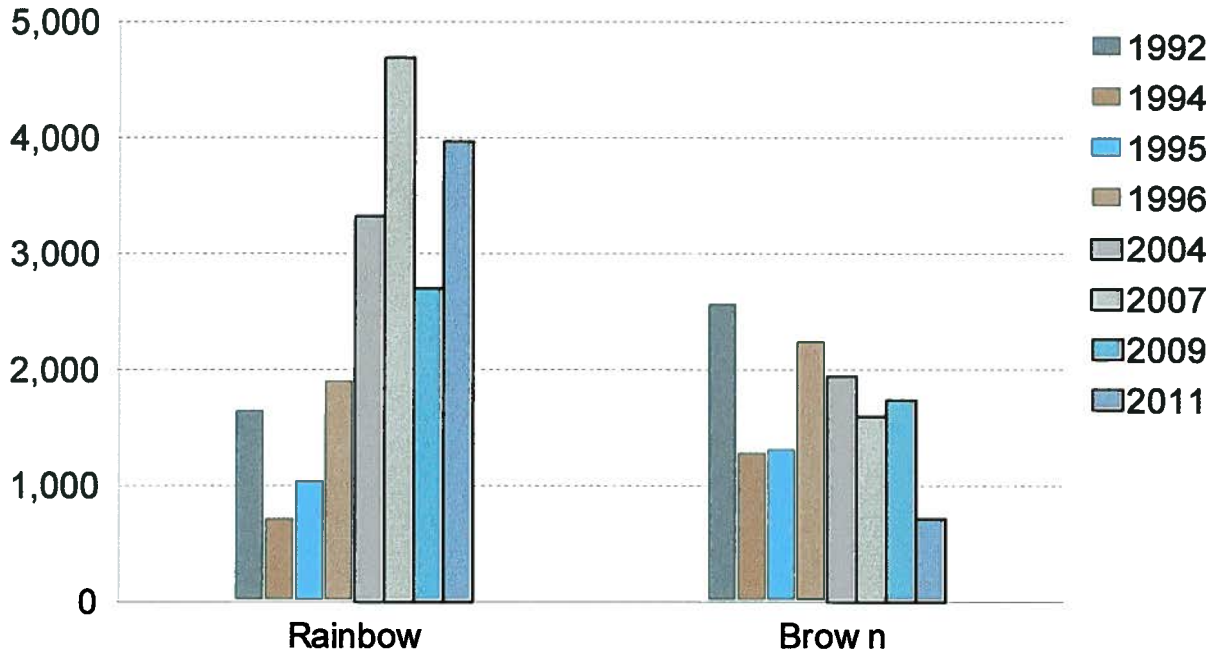


Figure 28. Population estimates (number/mile) of rainbow and brown trout in the Bypass section of the Madison River, spring estimates. PPL Montana personnel conducted the 1992 estimate.

in other river sections. Whirling disease did not have a severe population impact on trout in the Bypass and Norris sections downstream of Ennis Reservoir, presumably due to the different temperature regime than that of the river upstream of Ennis Reservoir.

**Ennis Reservoir Gillnetting**

Table 4 summarizes the 2011 gillnet data for Ennis Reservoir. As in previous years, Utah chub are the most abundant species. No whitefish have been captured in Ennis Reservoir gillnetting since 1999. In 1995, 1996 and 1999 a total of 6, 19 and 2 whitefish, respectively, were captured, with average length ranging between 11.9 and 14.5 inches.

Table 4. Summary of October 3 – 4, 2011 gillnet catch in Ennis Reservoir. Length is in inches, weight is in pounds.

| | UC[1] | WSu | Rb | LL |
|---|---|---|---|---|
| Avg.length | 9.1 | 11.0 | 13.1 | 15.5 |
| Avg.weight | 0.62 | 0.96 | 1.12 | 2.16 |
| Number sampled | 254 | 146 | 16 | 38 |

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

Charts illustrating the number captured, average length and species composition from 1995 - 2011 are in Appendix A3.

**Rainbow Trout Radio Telemetry**

Unsettled Spring weather in 2011 reduced the planned number of flights to locate rainbow trout implanted with transmitters in September and October 2009. Four fixed wing aircraft flights, three river floats, and six on-the-ground surveys were conducted from March through July, 2011.

Figure 29 illustrates documented movement greater than 0.2 miles of radio tagged Madison River rainbow trout during their March through July spawning period, 1999 versus 2010 and 2011. In 1999, 13 of 32 rainbow trout exhibited movement greater than 0.2 miles versus 27 of 33 relocated fish in 2010 and 5 of 18 relocated fish in 2011. In 2010, four rainbow trout exhibited initial upstream movements of 7.4, 9.1, 12.0 and 31.7 miles, then descended downstream for respective net movements of 5.4, -1.7, -11.5 and 3.7 miles. These fish are designated in Figure 29. In 2011, one rainbow trout that moved less than 0.2 miles in 2010 ascended 1.0 mile in 2011, 5 of the 27 rainbows tracked in 2010 exhibited movement greater than 0.2 miles from their last known 2010 location, 10 exhibited movement less than 0.2 miles, and 12 were either never located or their transmitter was recovered. One of the five fish that moved in 2011 descended 20.7 miles, none of the other four exhibited movement more than 2.5 miles (Appendix D). Two rainbow trout were relocated in the Bypass reach below Ennis Dam.

From March through July 1999, Downing (2000) documented rainbow trout spawning in the Madison River between river mile 45.3 (south shore of Ennis Reservoir) and river mile 109.1 (Hebgen Dam). He found that 17 of his radio implanted rainbow trout spawned in the mainstem river during that period, 13 upstream of Lyons Bridge (river mile 88.3). One of those ascended above Quake Lake to the vicinity of Cabin Creek. Nine of the 13 were captured, implanted and released upstream of Lyons Bridge. The other four moved upstream from locations 2.5 (near Moose Ck) – 34.2 (near Varney Bridge) miles below Lyons Bridge. He documented four other implanted rainbow trout spawning in the mainstem within 0 – 7.4 miles of their release locations near Moose Creek, 1 ½ miles upstream of McAtee Bridge, just below Varney Bridge, and ½ mile upstream of 8-Mile Fishing Access Site. He also documented four fish that moved into tributaries to spawn. Two of those fish made significant upstream movements from their September 1998 capture and release site just below Varney Bridge into Gazelle and Freezeout creeks in the West Fork Madison drainage, movements of 31.1 and 40.3 miles, respectively. One moved 5.8 miles downstream from its capture and release site, then ascended Squaw Creek 2.6 miles to spawn. The fourth rainbow moved 1 mile downstream then ascended 6 miles up the West Fork Madison to spawn. Downing (2000) found only one of the 17 mainstem river spawning radio implanted rainbow trout showed downstream movement of more than one mile during the 1999 spawning season (March – July), six showed movements of less than one mile either up or downstream, and 10 showed upstream movements of more than one mile (Figure 29).

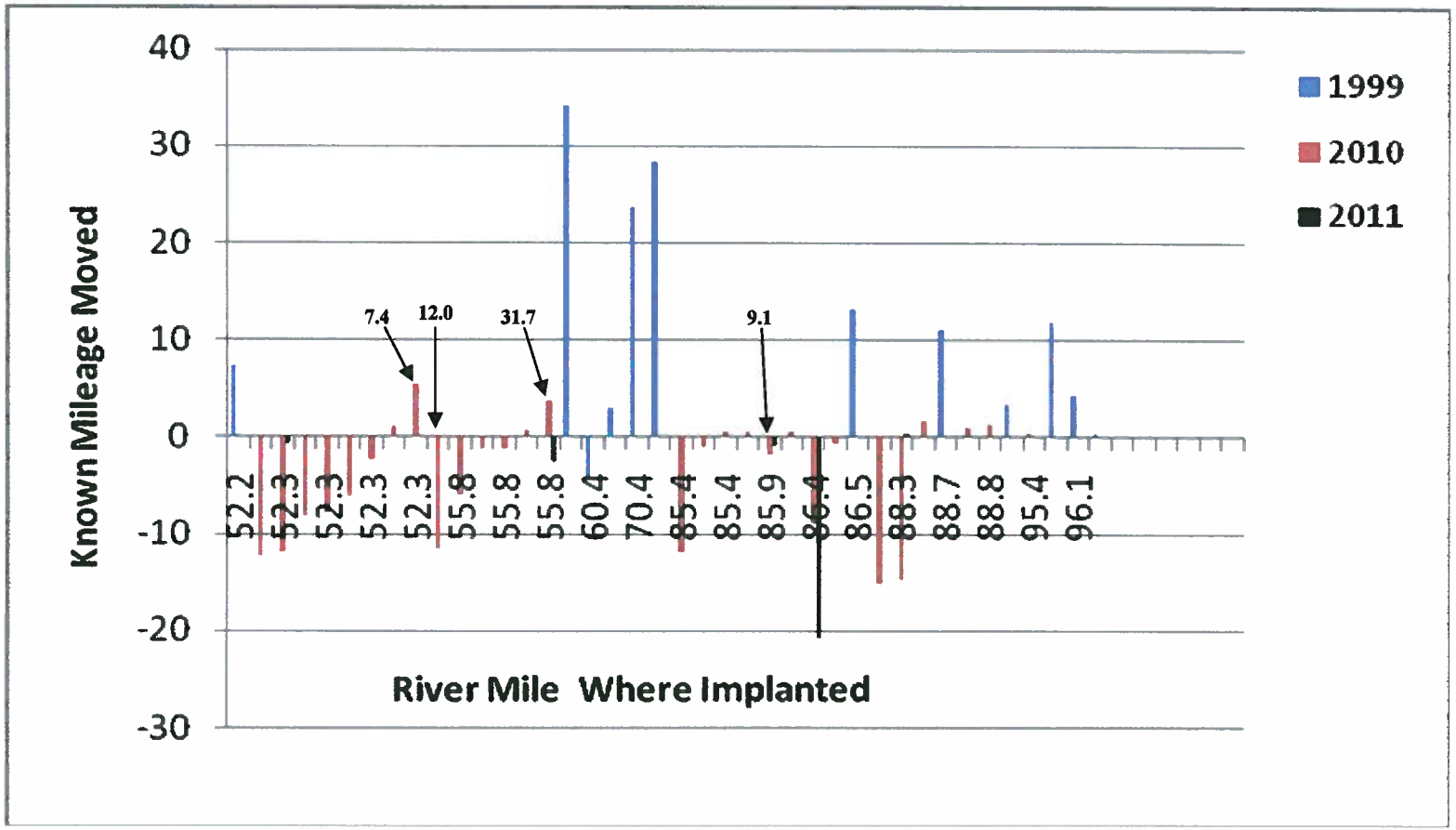


Figure 29. Known mileage moved by radio tagged rainbow trout March through July, 1999, 2010 and 2011. 2011 movements are from the last known 2010 location. Negative values indicate downstream movements, positive values indicate upstream movement. Fish that initially moved upstream then descended, all in 2010, are designated with an arrow and the upstream mileage moved. Reference locations are:

River mile 40.3 – Ennis Dam
50.6 – Highway 287 Bridge at Ennis
59.7 – Varney Bridge
74.6 – Ruby Creek
89.6 – West Fork Madison
101.4 – Quake Lake outlet

None of the rainbow trout involved in the 2010 – 2011 monitoring effort were documented to have ascended higher than river mile 95.0. The one fish that did ascend to river mile 95 was captured and implanted in September 2009 at river mile 85.9 (9.1 miles downstream of RM 95.0). This fish ultimately exhibited a net downstream movement of 1.7 miles (Figure 29).

**River Discharge**

*Pulse Flows*

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 were necessary every year from 2000 – 2007, but have not been necessary since except for two days in 2009, requiring 0.03 feet of draft in Hebgen Reservoir. Table 5, adapted from PPL Montana data, summarizes statistics regarding pulse flows in the Madison in years pulsing was conducted.

Table 5. 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 | 2.80 | 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 |
| 2009 | 6533.02 | 1.85 | 0.03 | 2 |

[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*

Due to the extreme and prolonged natural runoff, flushing flow releases from Hebgen Reservoir were not necessary in the Madison River in 2011.

*Minimum Flows*

Minimum and maximum instream flows in various sections of the Madison River are mandated in Article 403 and in Condition No. 6 of the FERC license to PPL Montana. Specifically, Condition 6 in its entirety states: "*During the operation of the facilities authorized by this license, the Licensee shall maintain each year a continuous minimum flow of at least 150 cfs in the Madison River below Hebgen Dam (gage no. 6-385), 600 cfs on the Madison River at Kirby Ranch (USGS gage no. 6-388), and 1,110 cfs on the Madison River at gage no. 6-410 below the Madison development. Flows at USGS gage no. 6-388 (Kirby Ranch) are limited to a maximum of 3,500 cfs under normal conditions excepting catastrophic conditions to minimize erosion of the Quake Lake spillway.*

*Establish a permanent flow gauge on the Madison River at Kirby Ranch (USGS Gauge No. 6-388). Include a telephone signal at the gauge for link to Hebgen Dam operators and the Butte-based System Operation Control Center.*"

**Temperature Monitoring**

Onset Tidbit™ temperature recorders were deployed throughout the Madison River to document air and water temperatures (Figure 8). Table 6 summarizes the data collected at each location in 2011, and Appendix E1 contains thermographs for each location. Appendix E2 compares maximum water temperatures at selected adjacent monitoring sites from 1997 – 2011. Appendix E3 contains annual longitudinal profiles illustrating the maximum water temperature recorded at each river monitoring site since 1997. It is important to note that the maximum temperatures at each site throughout the river did not all occur on the same day in any year, and that the maximum temperature at any given site may have been attained on more than just one day in a year. Some water temperature recorders were not recovered in some years, or the data recorder malfunctioned and the data were not recoverable, but for years where the data are available there are notable patterns:

- For all 12 years data are available, maximum water temperature at the Hebgen Inlet site is higher than maximum water temperature at the Hebgen discharge site
- The Ennis Reservoir Inlet site typically exhibits the highest maximum water temperature of the 7 sites between Hebgen Dam and Ennis Reservoir
- In 12 of the 14 years where data are available, maximum water temperature at the Ennis Dam site is lower than at the Ennis Reservoir Inlet site
- Maximum water temperatures at all sites below Ennis Dam typically are at least 5° F warmer than at Ennis Dam
- Maximum water temperature at Blacks Ford has been suppressed by pulse flows when necessary to prevent thermal stress related fish kills, the last of which occurred in 1988.

Table 6. Table showing maximum and minimum temperatures (°F) recorded at selected locations in the Madison River Drainage, 2011. Air and water temperature data were recorded from April 23 –October 5 (43,456 data points each recorder). Thermographs for each location are in Appendix E.

| | Site | Max | Min |
|---|---|---|---|
| Water | Hebgen inlet | 72.7 | 41.7 |
| | Hebgen discharge[1/] | -- | -- |
| | Quake Lake inlet | 67.8 | 35.3 |
| | Quake Lake outlet | 65.6 | 36.4 |
| | Kirby Bridge | 69.6 | 34.2 |
| | Wall Ck Bridge | 69.1 | 32.5 |
| | McAtee Bridge | 69.1 | 32.4 |
| | Ennis Bridge | 71.5 | 35.7 |
| | Ennis Reservoir Inlet | 73.0 | 36.5 |
| | Ennis Dam | 70.4 | 42.3 |
| | Bear Trap Mouth | 74.3 | 41.0 |
| | Norris | 74.5 | 40.7 |
| | Blacks Ford | 75.9 | 38.3 |
| | Cobblestone | 76.4 | 38.3 |
| | Headwaters S.P.[1/] (Madison mouth) | -- | -- |
| | | | |
| Air | Kirkwood | 97.3 | 12.7 |
| | Slide | 87.5 | 14.4 |
| | Wall Creek HQ | 92.0 | 17.7 |
| | Ennis | 94.0[2/] | 17.6 |
| | Ennis Dam | 89.8 | 23.3 |
| | Norris | 83.4 | 32.0 |
| | Cobblestone | 93.4 | 22.3 |

[1/] Recorders at Hebgen discharge & Headwaters State Park were not recovered.

[2/] Maximum temperature at Ennis air was 105.4, but the recorder had been exposed to full sun with a reflective metal background for a period of time. According to National Weather Service, the max air temp in Ennis was 94°F on August 28.

**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). The Aquatic Nuisance Species Task Force estimates that 42% of the species on the Threatened or Endangered species lists are significantly affected by alien-invasive species (www.anstaskforce.gov/impacts.php).

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

Within FWP Region 3 dissolved calcium levels measured in 2009 varied from 11mg/l at the Big Hole River Fish Trap FAS to 62 mg/l at Clark Canyon Reservoir. The sole site sampled in the Madison Drainage was Ennis Reservoir, which showed a calcium concentration between 20 – 24 mg/l. Calcium concentrations of 15 mg/liter or less are thought to limit the distribution of zebra/ and quagga mussels.

FWP ANS field crews found no Zebra or Quagga mussel veligers or adults, or Eurasian Watermilfoil in samples collected from Madison River sites in 2011. Both watercraft inspection stations at Madison River FAS locations found no contaminated boats, while 224 people were informed of AIS issues.

<u>New Zealand Mud Snails</u>

AIS sampling at Madison River locations revealed NZMS density at the footbridge area of Darlinton Ditch at Cobblestone FAS to be 8,420 per square meter, but samples were negative at river monitoring sites at Black's Ford, Greycliff and Cobblestone fishing access sites. It is unlikely that NZMS are truly absent from these sites, but more likely are at undetectably low levels.

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

1) Listing New Zealand mud snails as a Prohibited species in Montana.
2) Assisting in development of a regional management plan for New Zealand mud snails, an important portion of which will describe actions to be undertaken when New Zealand mud snails 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 mud snails or other ANS.
5) Purchasing portable power washing systems for cleaning boats and trailers at fishing access sites.

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

NZMS have not been found in any state or federal hatcheries in Montana. Strategies have been implemented to prevent the spread of NZMS from the sole private hatchery in which they were discovered in the state. The spread of New Zealand mud snails has slowed and appears to be confined in Montana 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 mud snails specifically, is available at www.esg.montana.edu/aim/mollusca/nzms.

### Whirling Disease

Caged young-of-the-year rainbow trout in the Madison River exhibited high whirling disease infection rates & severity from 1996 – 2010, exceeding the infection rate & severity level postulated by researchers to reduce rainbow trout population numbers. For rainbow trout, average histology scores above 2.5 are associated with high mortality of young-of-the-year and significant decreases in population.

The juvenile rainbow trout used in the sentinel cage studies were not offspring of Madison River rainbow trout, but were from a captive stock that was used in sentinel cages since studies began in 1996. The high infection rate exhibited by this captive stock shows that whirling disease remained at high levels in the Madison for 15 years, but offspring of Madison River rainbow trout appear to have developed a resistance to whirling disease as evidenced by rainbow trout population estimates in the upper river (Figures 22-24). 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 produced from the 2004 spawners exhibited a lower proportion of fish in the highly infective categories compared to those from 1998 spawners (Figure 30). In Figure 30, the average histology score of the 1998 test fish is 4.13, while that of the 2004 test fish is 2.42.

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 C.

### Sun Ranch Westslope Cutthroat Trout Program

Sixteen male and seven female Sun Ranch Brood fish were spawned in 2011, providing 1,666 eyed eggs. Recipient waters were Cherry Creek (848 fry) and the Sun Brood Pond (818 fry).

Over 7,500 eggs from donor stream wild populations were incubated at the Sun Hatchery in 2011. Eyed eggs or fry from wild sources were introduced into Cherry Creek and Cherry Lake, the East Fork of Specimen Creek Drainage in YNP, Cottonwood Creek in FWP Region 4, and the Sun Ranch brood pond.

Appendix G lists the contributions to and production of the Sun Hatchery since 2001, and Appendix H provides a list of streams for which PPL Montana funding has been used to test genetic purity.

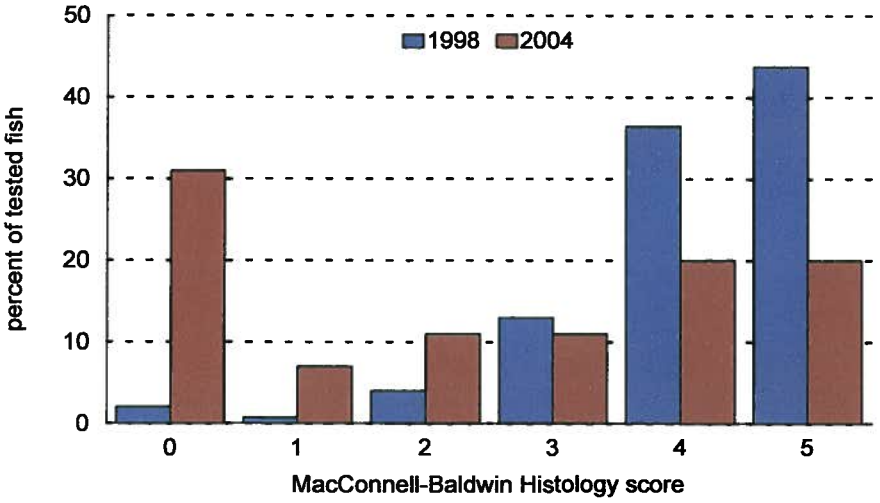


Figure 30. Figure showing the percentage of young-of-the-year Madison River rainbow trout within MacConnell-Baldwin histology ratings in 1998 and 2004. See Appendix F for MacConnell-Baldwin definitions.

Cherry Creek Native Fish Introduction Project

In 2011, no eyed eggs were introduced into the Cherry Creek Project area, but 848 Sun Ranch brood fry were introduced into Phase 4 of the project area (Figure 31). The Sun Ranch brood was developed from several wild donor populations. Additionally, Cherry Lake received its second planned introduction of WCT fry in 2011. The first introduction occurred in 2009. All WCT fry introduced into Cherry Lake were collected as eggs from White's Gulch, a tributary to Canyon Ferry Reservoir, then incubated and hatched in the Sun Ranch Hatchery. Additional wild westslope cutthroat introductions are planned for Cherry Creek Phase 4 in 2012 and Cherry Lake in 2013.

No triploid WCT fry or eggs were available for introduction into Cherry Creek in 2011. In 2010 approximately 400 triploid fry were introduced into Cherry Creek. These fry were uniquely marked so their growth & distribution can be determined when captured by electrofishing during routine monitoring efforts.

Personnel from FWP, Montana State University, Gallatin National Forest, and Turner Enterprises are conducting monitoring activities throughout the project area to assess survival, growth and distribution of the various donor populations that have been used to establish the Cherry Creek WCT population. Pending available funding, genetic samples from the developing population will be analyzed as the WCT population establishes and stabilizes to ascertain the proportion from each donor source relative to the proportion of eggs introduced. WCT have been documented to be pioneering up some tributaries where they were not introduced in phases 1, 3 and 4, and two anglers have reported catching WCT in the Madison River near the mouth of Cherry Creek, including photo documentation. Figure 32 shows an adult WCT captured in Cherry Creek that was introduced as a fertilized egg. Through 2011 approximately 75 percent of the project area has been surveyed with no non-native fish observed.

No rotenone was applied in the project area in 2011. Unless non-native fish are found in the project area during surveys, eradication efforts were completed in Cherry Creek in 2010.

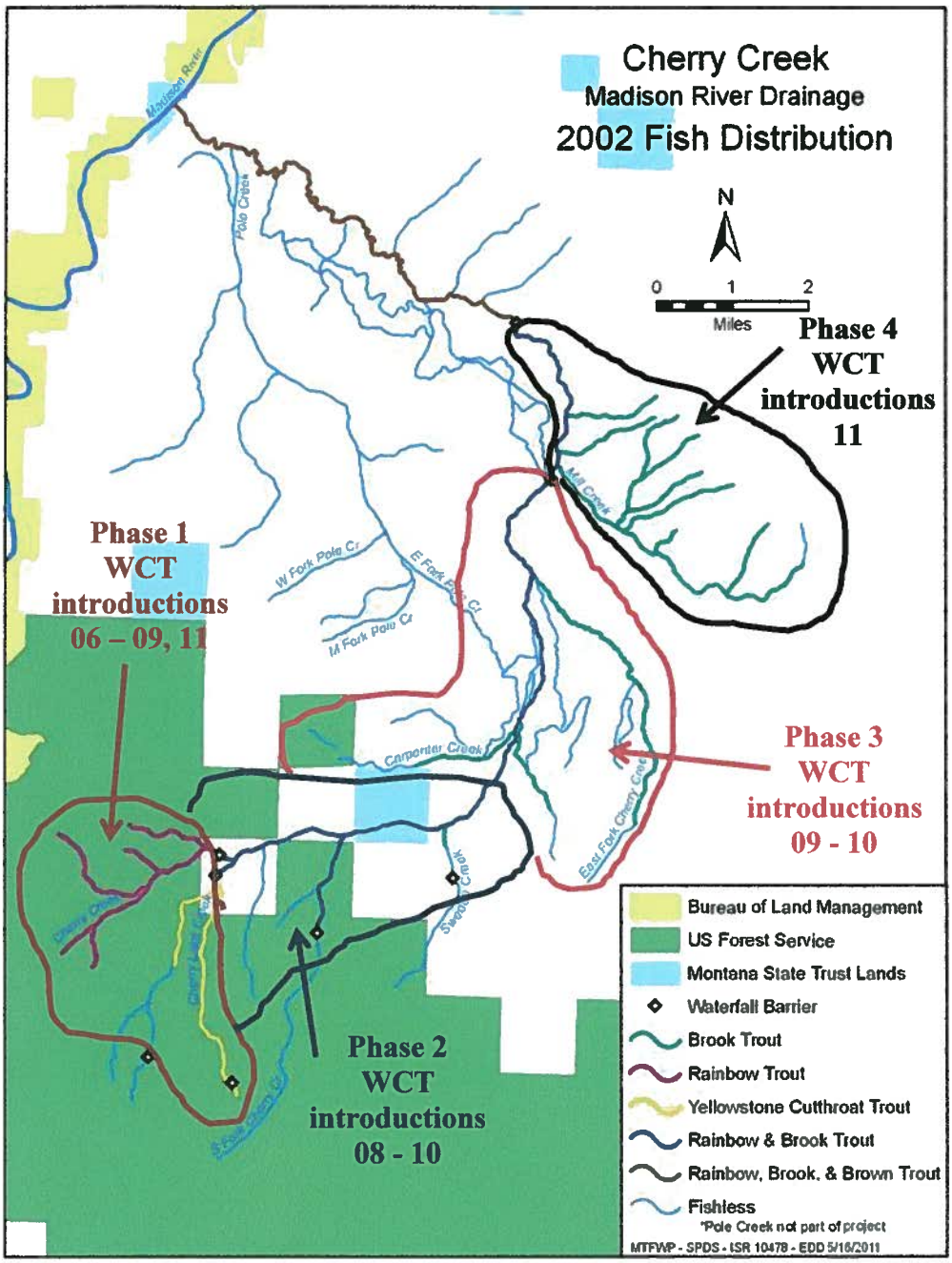


Figure 31. Phases 1 - 4 of the Cherry Creek Native Fish Introduction Project where westslope cutthroat trout were introduced in 2006 through 2011 following eradication of non-native Yellowstone cutthroat, rainbow, and brook trout in 2003 – 2010.

Figure 32. An 11.3 inch westslope cutthroat trout captured in Cherry Creek Phase 2 in 2010. This fish was introduced into Cherry Creek as a fertilized egg. FWP photo by Lee Nelson.

Monitoring of the trout population in lower Cherry Creek where rotenone ran farther than expected on August 4, 2010, causing a significant fish kill, documents recovery of that population. Sampling was conducted in the Wylie section in 2010 on August 11 and 27, and October 27, and in 2011 on September 1 and 12. In the Electric Gate section sampling was conducted August 11, 2010 and September 1, 2011. Figure 33 illustrates the results of electrofishing in two sections from 2001 – 2011. A nearly complete kill of trout occurred in the Wylie section (stream mile 5.6 – 6.0), while there was no discernible mortality in the Electric Gate section (stream mile 2.7 – 3.0). Though a 22 inch brown trout was captured in the Wylie section in 2011, resident rainbow and brown trout larger than 14 inches remain scarce in that section relative to before the incident. In the Wylie section, brown trout spawning was documented in October 2010, and rainbow trout spawning documented in April 2011.

**Fish Habitat Enhancement**

Smith Lake

With de-activation of the aged stock water delivery system at Smith Lake Dam on Lake Creek in, a tributary to the West Fork Madison, the new stock water system is performing as designed (Jake Stewart, Madison Ranger District, pers. comm.). Personnel from the Beaverhead-Deerlodge National Forest observed several adult male brown trout in spawning condition on October 11 in Lake Creek above Smith Lake (Figure 34).

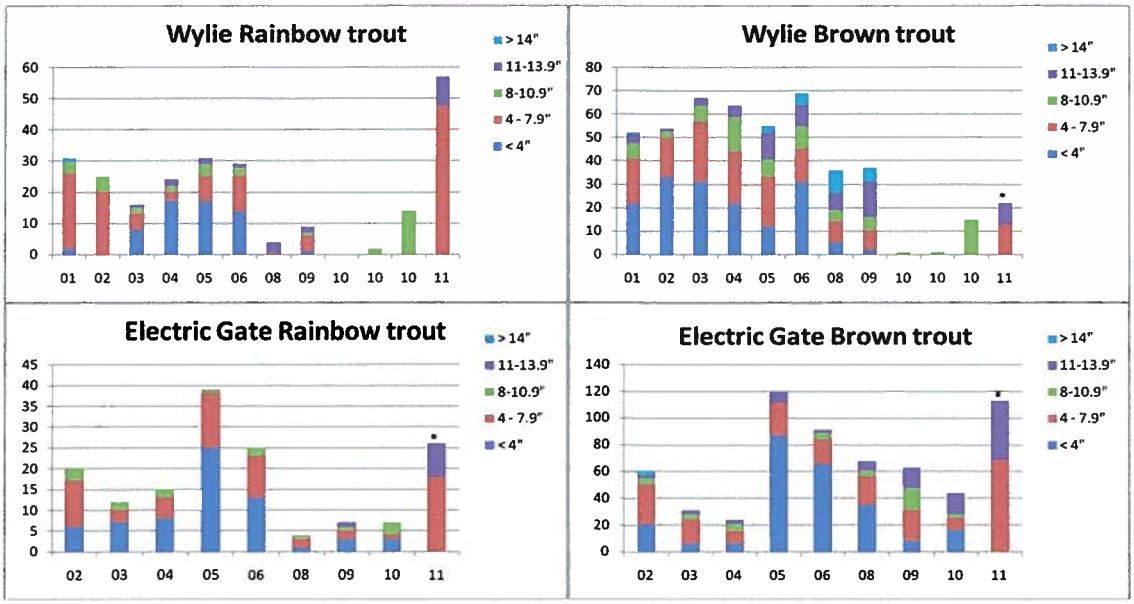


Figure 33. Characteristics of late Summer/Autumn rainbow and brown trout populations in two sections of lower Cherry Creek, 2001 – 2011. In 2011, fish were measured only as less than or greater than 10 inches. 2001 – 2009 data collected by Turner Enterprises, Inc., under an FWP collectors permit.

Table 7. Schedule of Cherry Creek piscicide treatments, the number of stream miles treated, number of worker days, and quantity of piscicide used, 2003 – 10.

| Year | Phase | miles treated[1/] | # worker-days | piscicide quantity |
|---|---|---|---|---|
| 2003 | 1 | 11 | 284 | 4.9 gallons Antimycin |
| 2004 | 1 | 11 | 240 | 6.4 gallons Antimycin;<br>1.0 gallon rotenone |
| 2005 | 2 | 8 | 220 | 7.0 gallons antimycin<br>1.0 gallons rotenone lqd<br>1 lb rotenone pwdr |
| 2006 | 2 | 8 | 256 | 5.9 gallons Antimycin |
| 2007 | 2, 3 | 4, 23 | 264 | 9.0 gallons rotenone |
| 2008 | 3 | 23 | 158 | 14.6 gallons rotenone<br>2 lbs rotenone pwdr |
| 2009 | 3 | 5 | 16 | 5.7 gallons rotenone<br>0.5 lbs. Rotenone pwdr |
| 2010 | 3, 4 | 5, 12 | 200 | 22.4 gallons rotenone |

[1/] The number listed represents the number of stream miles covered in one treatment. In some years multiple treatments occurred in a given area, e.g. in 2010 all 12 miles of Phase 4 were treated twice, and the mainstem three times, so the total miles treated in Phase 4 in 2010 was 27.

Figure 34. Photo of a male brown trout in Lake Creek upstream of Smith Lake Dam. USFS photo by Nick Peterson.

## Jack Creek

Reconstruction of the Jack Creek channel was completed in 2010. By increasing sinuosity, designers increased channel length from approximately 1,290 linear feet to 1,518 linear feet, a nearly 18 percent increase. Additionally, fish habitat features and riparian vegetation were incorporated into the channel reconstruction.

Fisheries monitoring was conducted in the Jack Creek Ranch section April 2008 and 2010 prior to channel reconstruction, and in 2011 after channel reconstruction (Figure 35). Additionally, the fish population in a nearby unaltered reach of stream (Madison Valley Ranch section) was monitored as a control. Fish population monitoring in these two reaches will continue periodically for several years as the newly constructed channel matures.

A rainbow trout spawning run was documented in Jack Creek during the 2008 fish monitoring. Subsequent work with this spawning run has shown that these fish migrate as far as 8 miles up Jack Creek to spawn. It is unknown how long this spawning run has been occurring. It may have developed as a result of the apparent localization of rainbow trout spawning suggested by the results of the 2010 rainbow trout radio telemetry study (Figure 29).

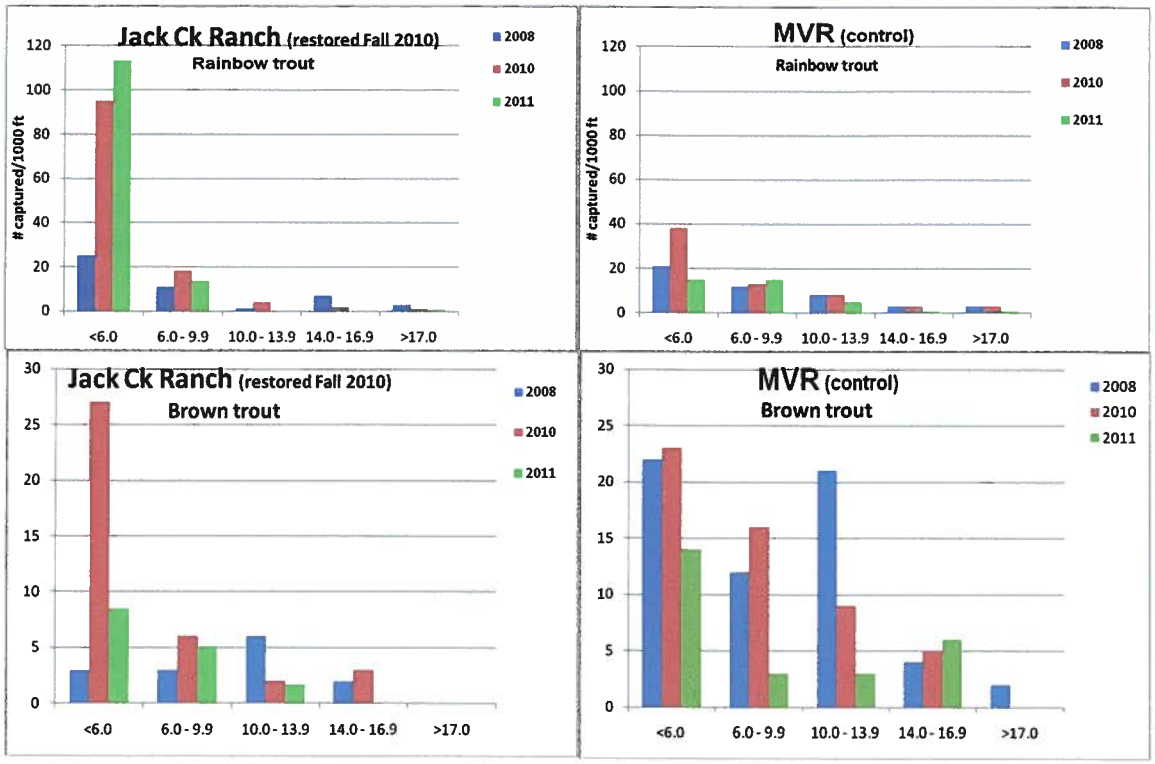


Figure 35. Number of rainbow (top charts) and brown (bottom charts) trout by size class in April in two sections of Jack Creek. Channel reconstruction of the Jack Creek Ranch section occurred in the Fall, 2010.

South Fork of Meadow Creek

Design and bid awarding to rebuild irrigation infrastructure, including in-stream weirs and headgates, were completed in 2011 with construction scheduled to begin in 2012. There will be no stream channel modifications as part of this project, but the stream corridor will be fenced creating a 30-foot zone on each side of the stream where livestock grazing is prevented.

Fish populations were sampled in two sections of the project area in September 2011 (Figure 36) with additional sampling scheduled for Spring and Fall 2012 as well as for several years after project completion. Stream channel morphology will be monitored and photographed prior to fence construction and also for several years after fence construction to document changes that occur.

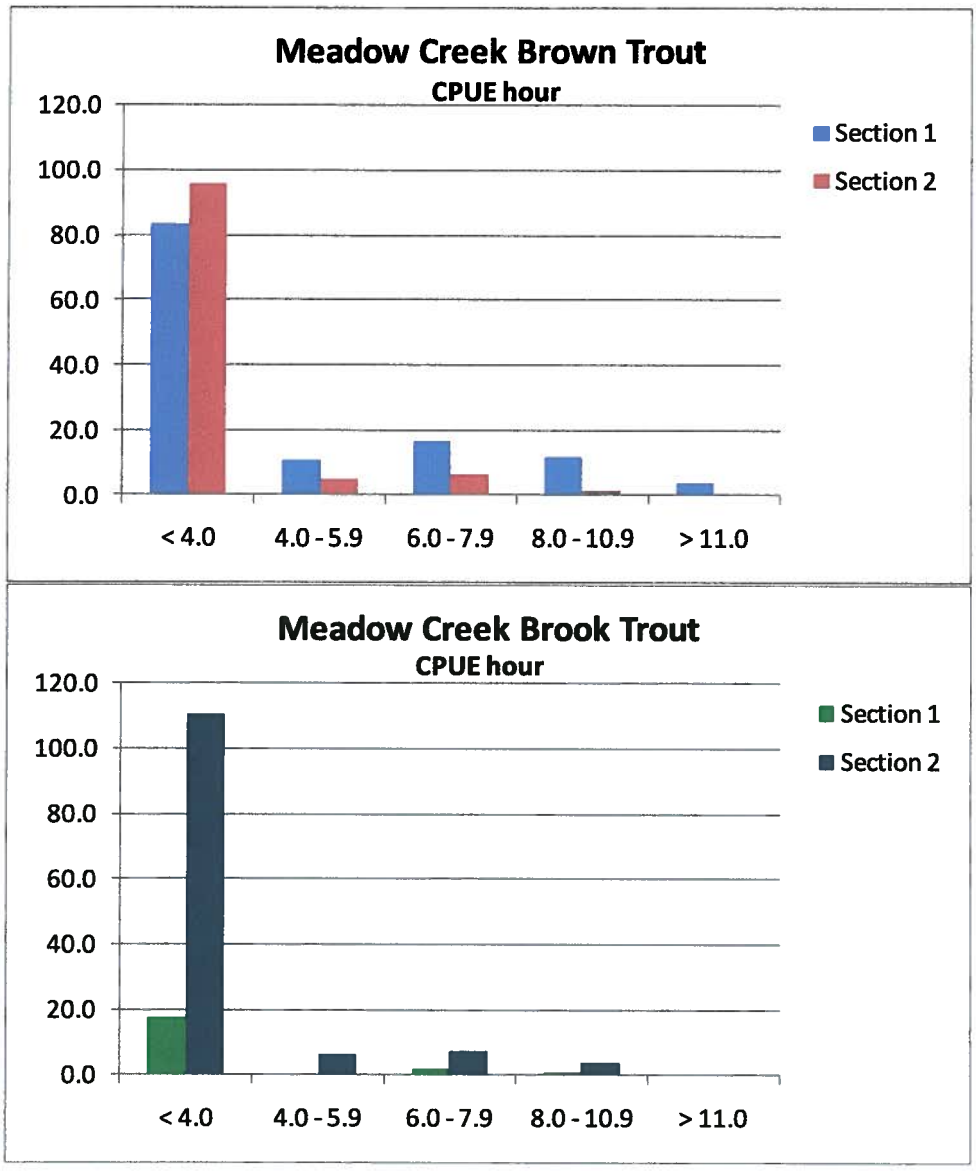


Figure 36. Catch-per-unit-effort (hour) of electrofishing for brown and brook trout in two sections of the South Fork of Meadow Creek, September 2011.

**Hebgen Basin**

Hebgen Reservoir Gillnetting

A total of 738 fish were captured during Hebgen Reservoir gillnetting in 2011 (Table 8), over half of them were Utah chub *Gila atreria*.

The number of rainbow trout captured by gillnetting has decreased for three consecutive years since the peak number captured (Figure 37). The number of rainbows captured per year has varied from 40 in 2001 to 194 in 2008. No rainbow trout tagged in tributaries with coded-wire or Floy™ tags were captured during gillnetting in 2011.

Table 8. Summary of 2011 Hebgen Reservoir gillnet catch.

| Species | Number caught | Average Length (range) | Average weight (range) |
|---|---|---|---|
| Rainbow trout | 69 | 16.5 (8.2-19.9) | 1.66 (0.18-2.57) |
| Brown trout | 142 | 16.9 (7.0-22.6) | 1.72 (0.14-3.29) |
| Whitefish | 102 | 16.9 (10.0-21.8) | 1.86 (0.42-3.30) |
| Utah Chub | 425 | 11.8 (5.7-15.6) | 0.83 (0.06-1.90) |

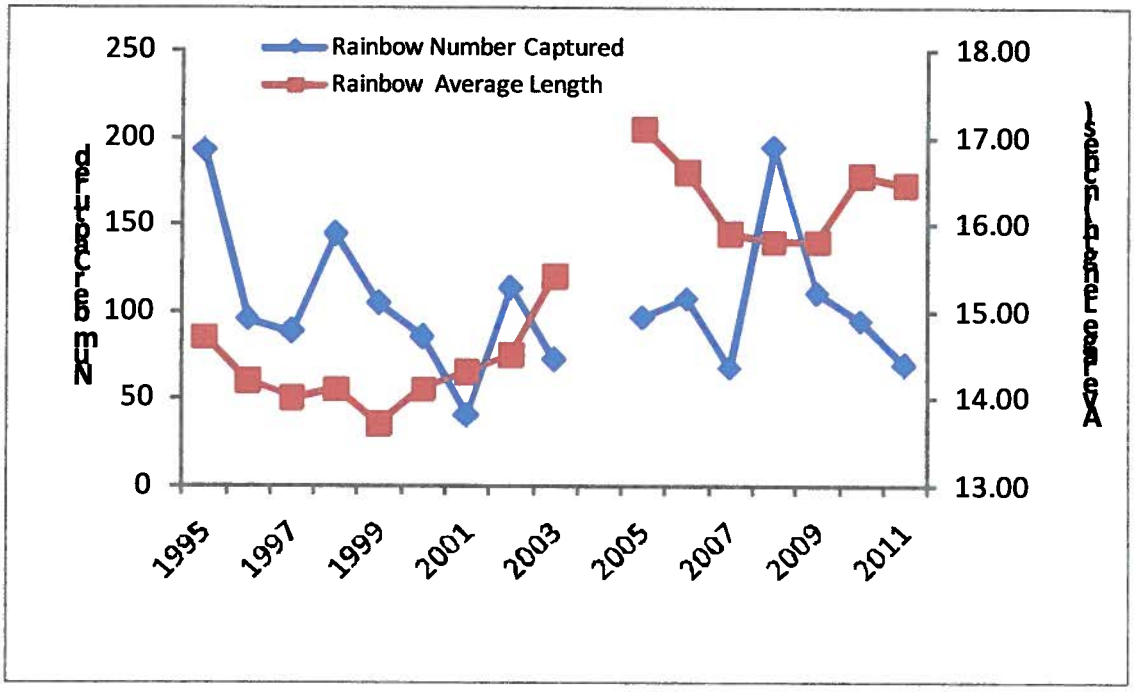


Figure 37. Figure showing rainbow trout average length in inches (right axis) vs. number captured (left axis) during annual Hebgen gillnetting, 1995-2011. Data from 2004 are not shown because of sampling error.

Average length of rainbow trout captured has been higher over the last decade than in the mid-late 1990's. Additionally, the proportion of the rainbow trout gillnet catch under 14 inches has decreased noticeably since 2003 (Figure 38).

Vertebrae from 51 rainbow trout were examined for tetracycline marks, but only one was positive (2.0%), indicating a fish of hatchery origin. The sole tet-positive fish was 17 inches long and also exhibited hatchery dorsal fin erosion. Dorsal fin erosion is often associated with hatchery produced trout. Applying the 2.0% tetracycline ratio to the total number of rainbow captured (69) only this one rainbow trout can be assigned to hatchery origin. Over 300,000 rainbow trout were stocked in Hebgen Reservoir in 2008 compared to an annual average of 90,800 in 2005-2007, but given the length of the tet-positive rainbow it is likely that it was stocked prior to 2008.

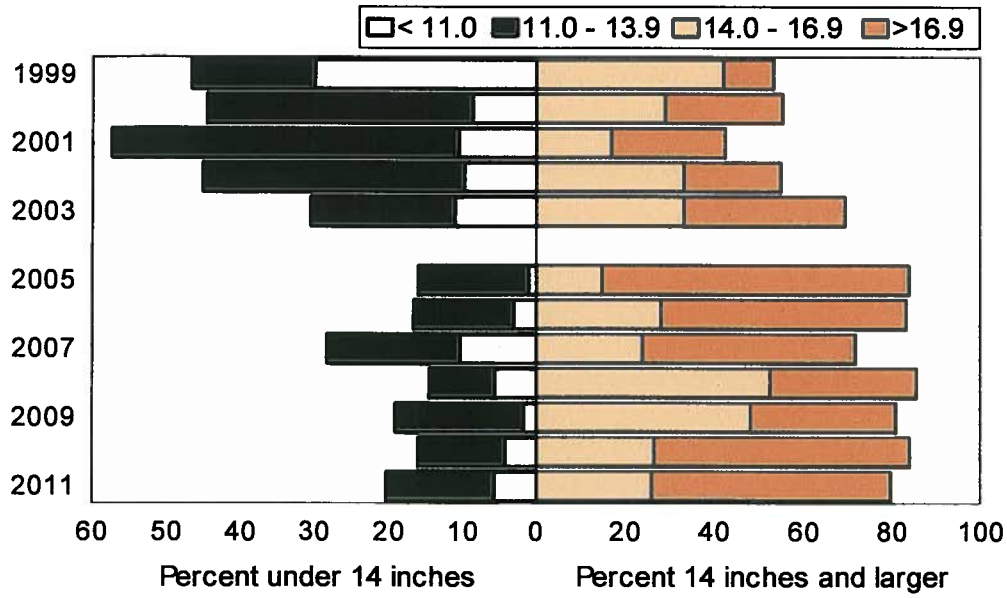


Figure 38. Figure showing percentage of Hebgen Reservoir rainbow trout gillnet catch under and over 14 inches, 1999-2011. Data from 2004 are not shown because of sampling error.

Brown trout numbers have fluctuated widely with no consistent trend evident for more than a few consecutive years (Figure 39). The number of fish captured annually has ranged from 40 in 2001 to 326 in 1999. One brown trout captured during 2011 gillnetting held a yellow Floy™ tag, inducating it had been captured and handled during the fall of 2008 at the Madison weir.

The number of whitefish captured decreased significantly in 2002, but has remained relatively stable in recent years (Figure 40). The number captured per year has varied from 80 in 2002 to 235 in 1999. Average length has shown a generally upward trend.

The number of Utah chub captured decreased significantly in 2005 and has remained low since. Average length has shown no consistent trend since 1995 (Figure 41). The number of Utah chub captured annually has ranged from 268 in 2008 to 2,245 in 1999.

Utah chub comprised nearly 80 percent of the total Hebgen gillnet catch in 1995-2003 but have averaged slightly less than 60 percent since (Figure 42).

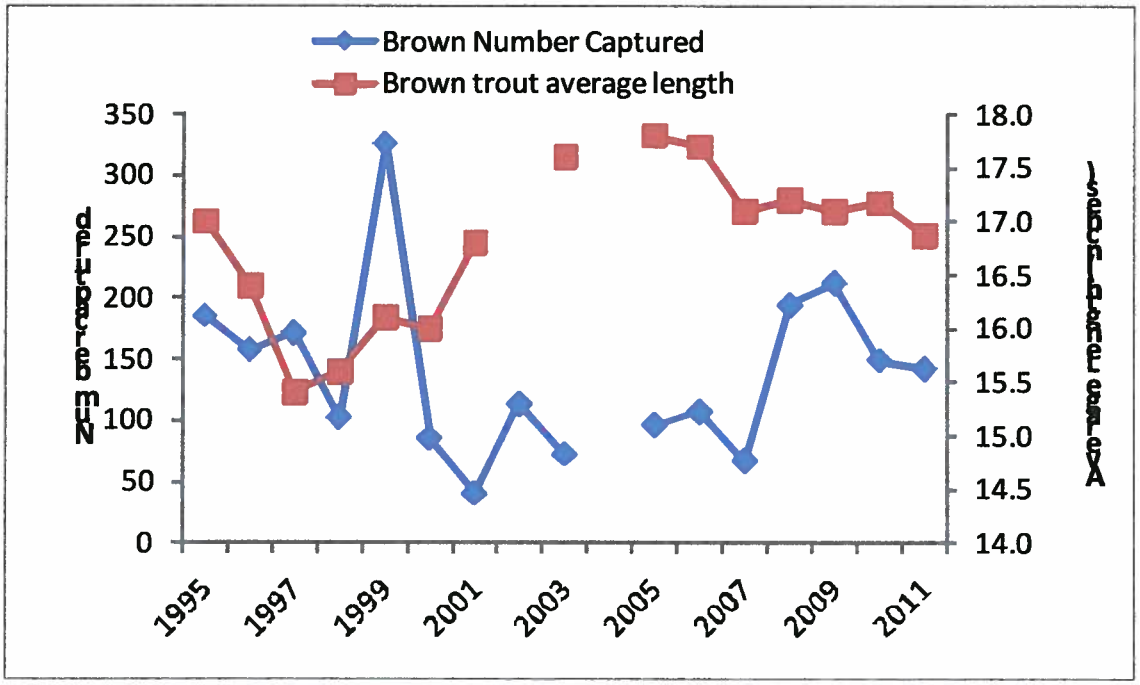


Figure 39. Figure showing brown trout average length in inches (right axis) vs. number captured (left axis) during annual Hebgen gillnetting, 1995-2011. Data from 2004 are not shown because of sampling error.

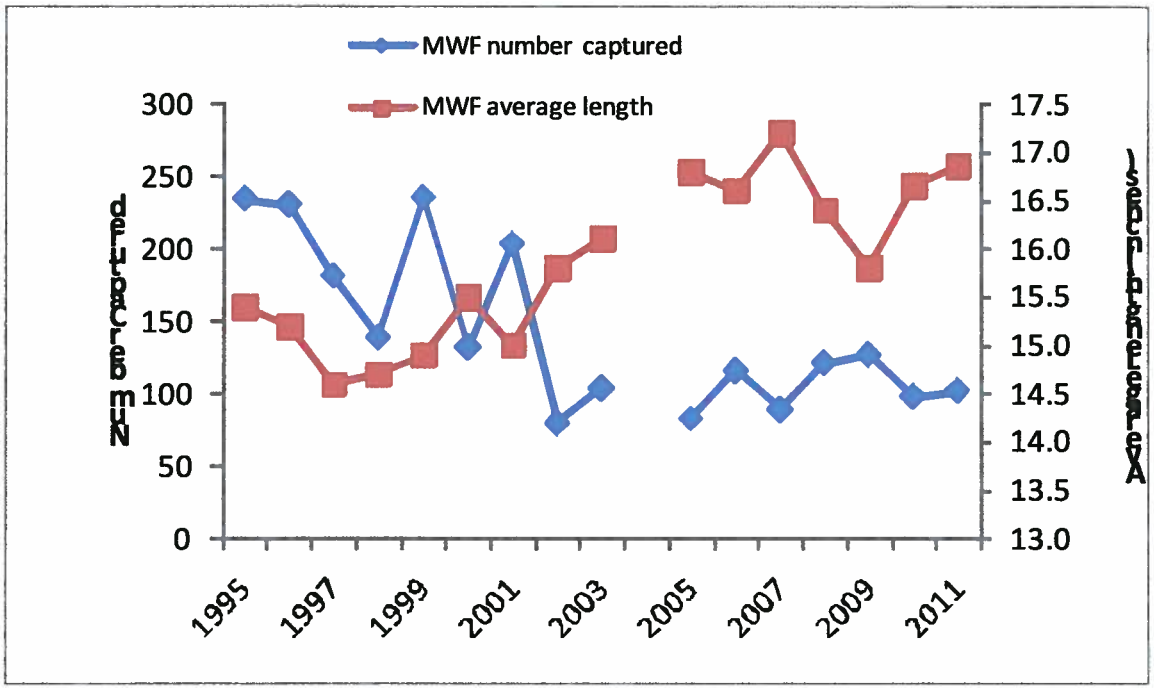


Figure 40. Figure showing mountain whitefish average length in inches (right axis) vs. number captured (left axis) during annual Hebgen gillnetting, 1995-2011. Data from 2004 are not shown because of sampling error.

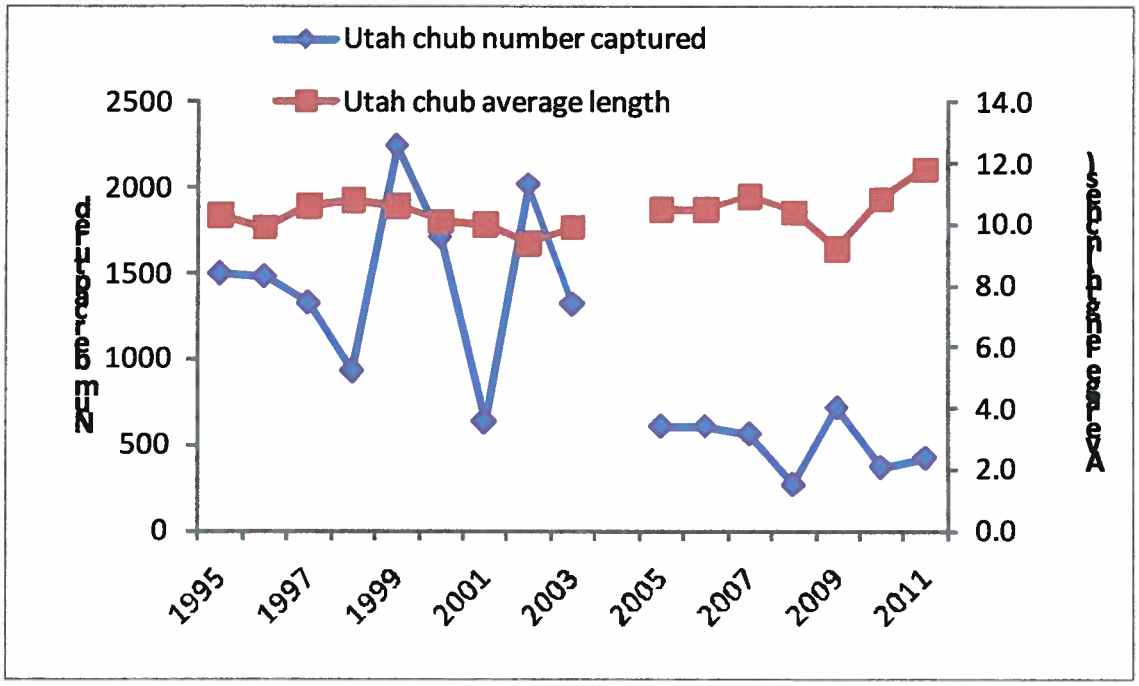


Figure 41. Figure showing Utah chub average length in inches (right axis) vs. number captured (left axis) during annual Hebgen gillnetting, 1995-2011. Data from 2004 are not shown because of sampling error.

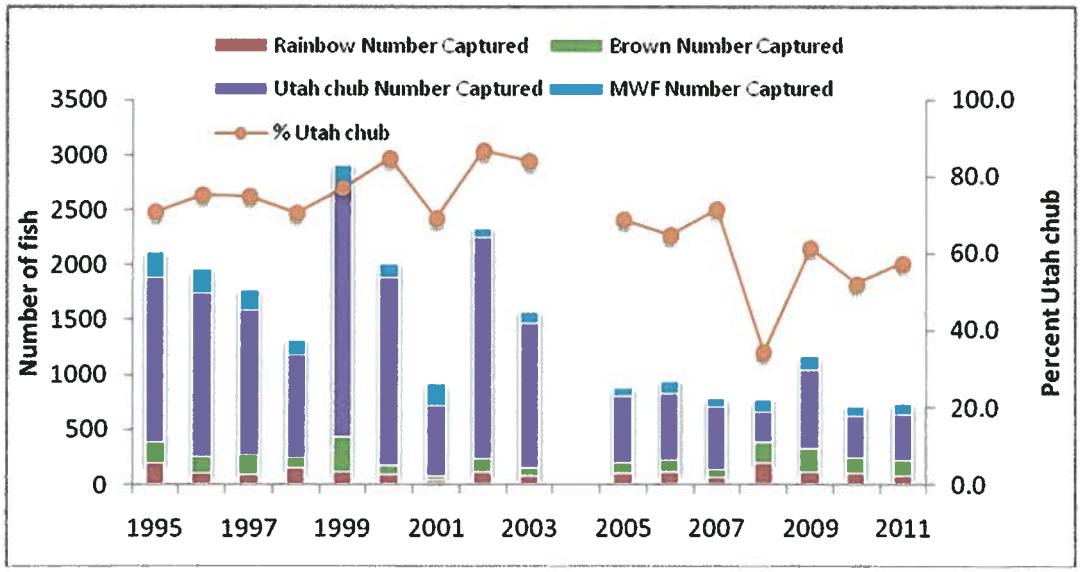


Figure 42. Figure showing species composition of Hebgen Reservoir gillnet catch, 1995 – 2011. Data from 2004 are not shown because of sampling error.

## Hebgen Reservoir Tributary Habitat Improvement Monitoring

*South Fork Madison Large Woody Debris Project*

Relative abundance of rainbow and brown trout has decreased significantly in two sections of the South Fork Madison River that underwent a large woody debris habitat improvement projects in 2005 and 2006 (Figure 43; Clancey 2006). The goal of the projects was to enhance spawning and rearing habitat for rainbow trout. Electrofishing was not conducted in Phase 1 in 2011, but in Phase 2 rainbow trout were completely absent, only one brown trout was captured, and brook trout numbers had decreased as well. The initial response of the species assemblage in Phase 2 after project completion in 2006 was positive, with 229 brown and 21 rainbow trout sampled in 2007 compared to 8 brown and 12 rainbow trout sampled in 2005 prior to project implementation.

While the goal of the project was to enhance spawning and rearing habitat for rainbow trout, it likely increased inter-specific competition for habitat and forage. Investigations of westslope cutthroat and eastern brook trout interactions in Montana streams indicate that the rate of displacement of westslope trout through brook trout invasion are likely related to stream habitat conditions such as pool abundance and woody debris (Shepard 2004). Brook trout prefer habitats that contain wood debris, and the carrying capacity of adult brook trout in streams is influenced by the presence of cover supplied by submerged brush and logs, undercut banks, large rocks, and overhanging vegetation (Flebbe and Dollof 1995; Saunders and Smith 1965; Elwood and Waters 1969; O'Connor and Power 1976).

The lower number of fish observed in Phase 2 in 2011 is likely a function of high flows during a prolonged spring runoff which caused several of the debris jams constructed in 2006 to be displaced downstream or deposited on the stream banks (Figure 44). Only six of the original 24 structures constructed were remaining in the project reach after 2011 runoff. This reduction in available habitat likely influenced fish movement from the reach to areas with greater habitat availability.

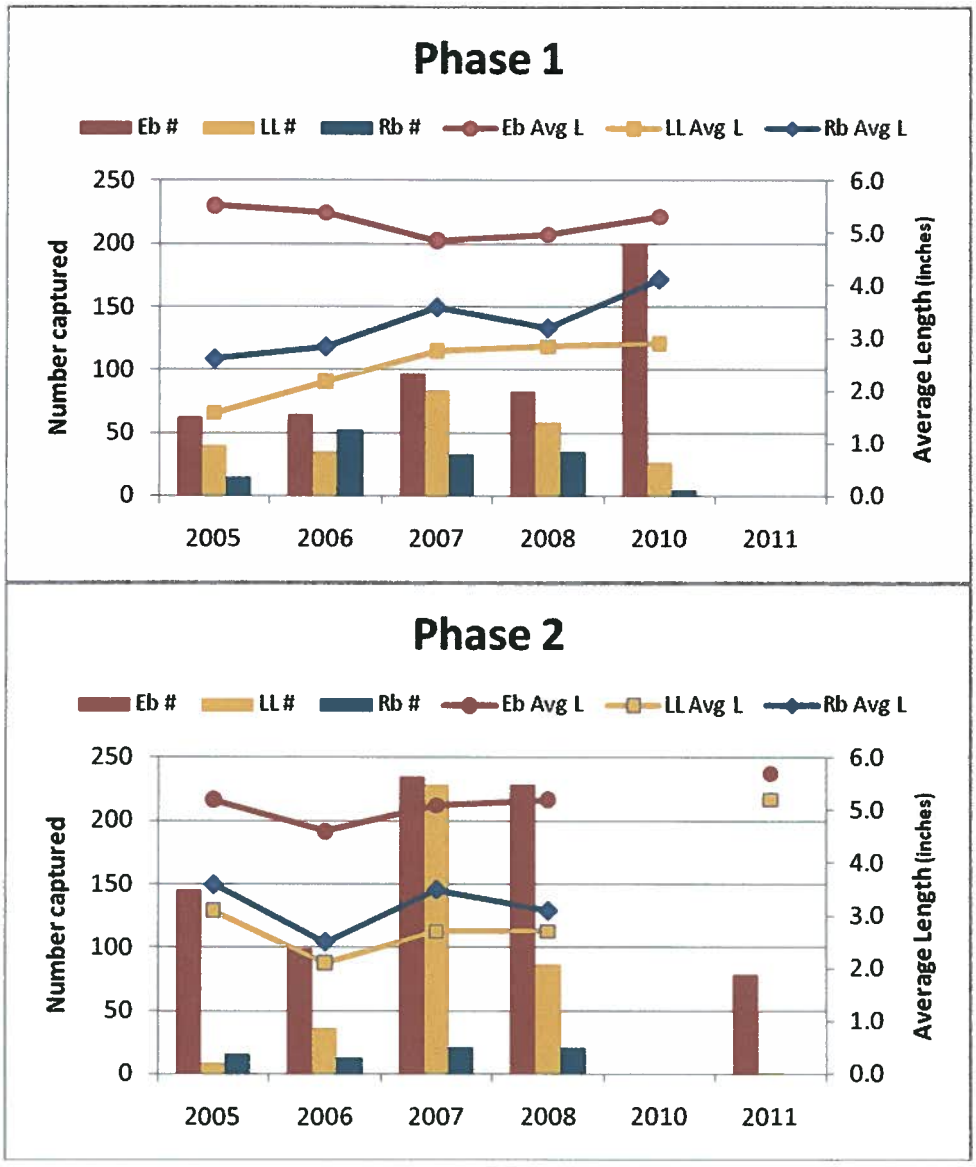


Figure 43. Figure showing the relative abundance and average size of rainbow (Rb), brown (LL) and brook (Eb) trout in two sections of the South Fork Madison River following a large woody debris habitat improvement project in 2005.

Figure 44. Photo of large woody debris in Phase 2 of the South Fork Madison River deposited on the stream bank by high flows during spring runoff 2011.

*Watkins Creek*

FWP personnel conducted two fish population surveys of the Watkins Creek a large woody debris (LWD) project in 2011 (Table 9; Appendix C). Only the LWD project and downstream control reach were sampled during the first sampling event on July 18th as high stream flows made sampling in the upstream control ineffective. A second survey of all monitoring reaches was conducted on August 31 when stream discharge had returned to base flows.

Table 9. Summary of electrofishing monitoring conducted for Watkins Creek LWD project, 2011.

| Section | Sample Date | Number of Salmonids Captured | Effort (seconds) | Catch-per-Unit-Effort (fish/hour) |
|---|---|---|---|---|
| Upstream Control | 8/31/11 | 15 | 1695 | 32 |
| Project Section | 7/18/11 | 3 | 0833 | 13 |
| | 8/31/11 | 11 | 1626 | 24 |
| Downstream Control | 7/18/11 | 7 | 1060 | 25 |
| | 8/31/11 | 28 | 1864 | 54 |

Rainbow trout, rainbow x Yellowstone cutthroat trout hybrids and Rocky Mountain (mottled) sculpin were the only fish species sampled in the Watkins Creek project area and control sites. Catch-per-unit-effort and average length of rainbow and rainbow-cutthroat is shown in Figure 45. Capture efficiencies for size

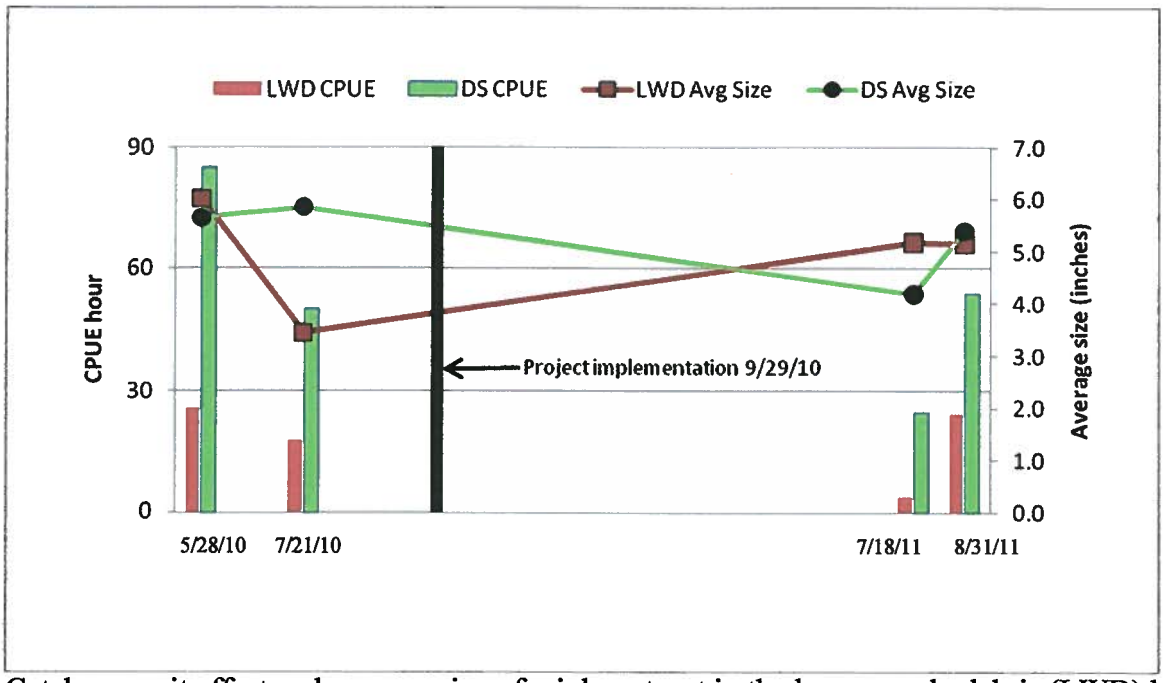


Figure 45. Catch per unit effort and average size of rainbow trout in the large woody debris (LWD) habitat improvement section and the downstream (DS) control section of Watkins Creek, 2010-2011.

groups in August 2011 were likely affected by higher than average flows. Comparisons of data sets are difficult as both sampling efforts in 2011 were conducted approximately one month later than the 'equivalent' sample in 2010, again, due to significantly higher and prolonged stream discharge in 2011 than in 2010.

## Hebgen Basin Juvenile Fish Sampling

Screw traps were not operated on any Hebgen Reservoir tributaries in 2011.

### *Beach Seining*

Beach seining has been conducted intermittently to monitor juvenile fish numbers in Hebgen Reservoir. Figure 46 illustrates total catch at three index sites for 2007, 2008 and 2011.

Numbers of juvenile chubs have consistently been low in June and shown dramatic increases in July, which may be a function of their size. Graham (1955) found peak spawning of Utah chub in Hebgen occurred mid June to early July in shallow near-shore zones often with submergent or emergent vegetation and inundated terrestrial vegetation. The low number of young-of-the-year Utah chub observed in July 2007 and conversely the relatively high number observed in 2008 and 2011 may be related to reservoir elevation and how it affects the availability of spawning habitat utilized by Utah chub (Figure 47). Reservoir elevation decreased by 1.32 feet from June to July 2007. Teuscher and Lueke (1996) suggest vegetation as a key component to successful Utah chub spawning. Differences observed in the number of young-of-the-year Utah chub throughout the years may be a function of reservoir elevation on Utah chub access to inundated shoreline vegetation.

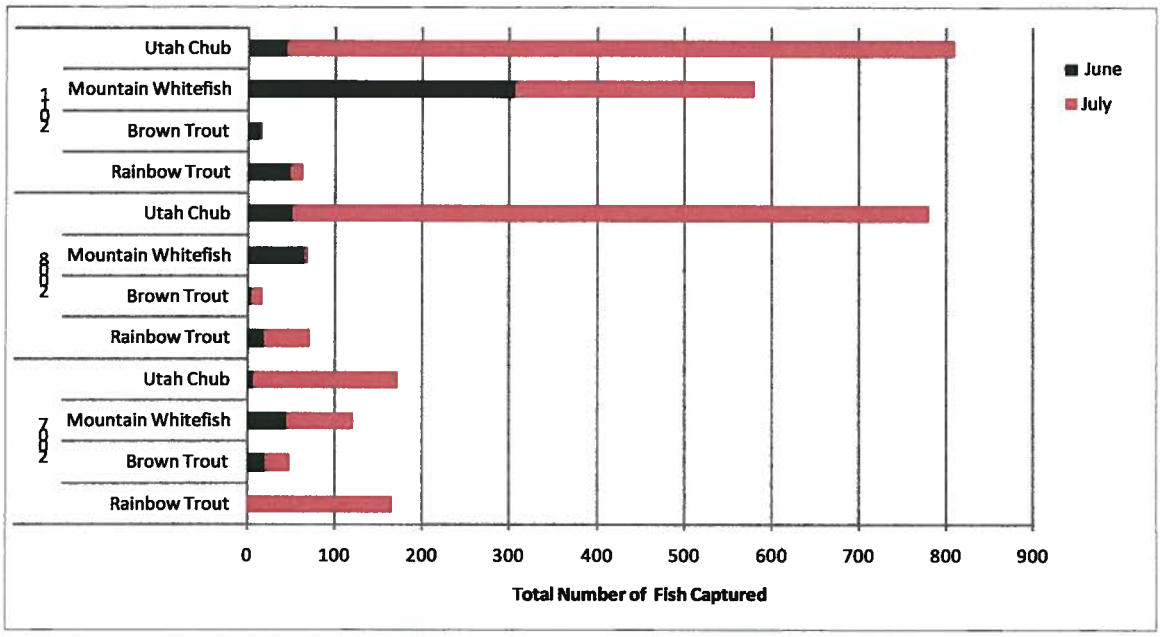


Figure 46. Beach seining catch of juvenile Hebgen Reservoir fish, June and July, 2008, 2009 and 2011.

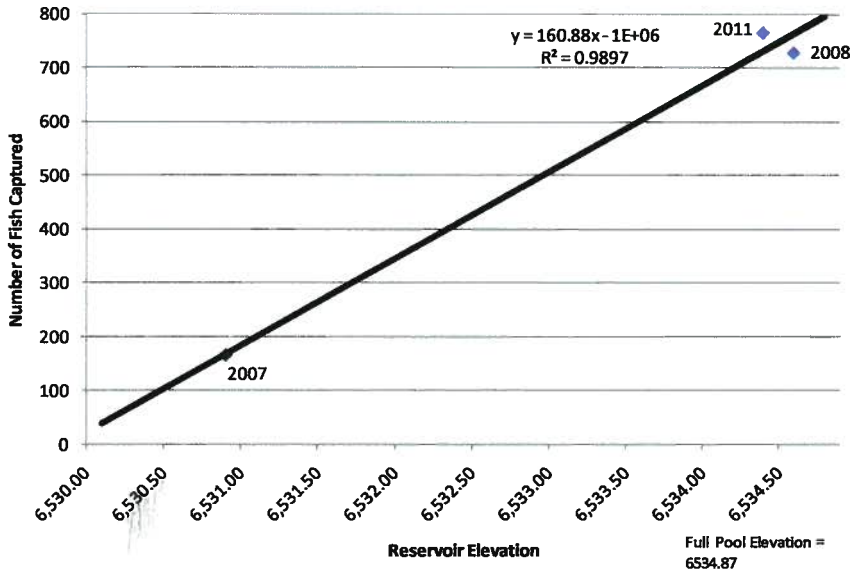


Figure 47. Number of young-of-the-year Utah chub collected during July seining of index sites versus reservoir elevation 2007, 2008 and 2011.

## Hebgen Basin Disease Monitoring

*Whirling Disease*

Whirling disease monitoring was not conducted in the Hebgen Basin in 2011, however, results of previous years monitoring are shown in Table 10.

Table 10. Whirling disease scores for tributaries of Hebgen Reservoir, 2007 - 2010. Sentinel fish from 2009 were inadvertently destroyed prior to completion of the required 90 day incubation period, therefore test results are unavailable for 2009.

| Year | Site | Test Period | WD score |
|---|---|---|---|
| 2007 | South Fork | May 10 – 20 | 4.29 |
| | | May 20 -30 | 4.66 |
| | | May 30 – Jun 9 | 3.96 |
| | | Jun 9 -19 | 3.67 |
| | | Jun 19 - 29 | 2.52 |
| | Black Sands Spring | May 10 – 20 | 0.02 |
| | | May 20 -30 | 0 |
| | | May 30 – Jun 9 | 0 |
| | | Jun 9 -19 | 0 |
| | | Jun 19 - 29 | 0 |
| | Duck Ck | May 10 – 20 | 0.12 |
| | | May 20 -30 | 0 |
| | | May 30 – Jun 9 | 0.08 |
| | | Jun 9 -19 | 0.06 |
| | | Jun 19 - 29 | 0 |
| 2008 | South Fork | Jun 18 – 28 | 3.30 |
| | | Jun 28 – Jul 8 | 2.46 |
| | Duck Ck | Jun 18 – 28 | 0 |
| | | Jun 28 – Jul 8 | 0 |
| | Cougar Ck | Jun 18 – 28 | 0 |
| | | Jun 28 – Jul 8 | 0 |
| | Grayling Ck | Jun 18 – 28 | 0 |
| | | Jun 28 – Jul 8 | 0 |
| 2010 | South Fork | May 16 – 26 | 1.09 (Highway 20) |
| | | | 0.62 (1/4 mile above Highway) |

Primary productivity in Hebgen Reservoir may be limited by climate conditions. A high elevation short-duration growing season allows for relatively few days of primary production. Hebgen Reservoir, with a full pool elevation of 6,534.87 feet, may be more characteristic of an alpine lake than of lakes at lower elevations. Johnson and Martinez (2000) found lake elevation and a shortened growing season (the number of days water surface temperature is at or exceeds 50°F) to be inversely related to lake productivity. Mean daily surface water temperatures for Hebgen over the last five years equaled or exceeded 50° F an average of 130 days. In 2007, surface temperatures equaled or exceeded 50° F for 152 days, extending the growing season by almost a month, which may have contributed to the increase in cladoceran densities observed. Additionally, wind patterns may be inhibiting the mixing of nutrients from tributaries entering Hebgen with the main body of the reservoir. For the months of June through October, 2007-2009, at the West Yellowstone airport, wind direction was predominately out of the northwest (Figure 52). Given Hebgen Reservoirs northwest-southeast orientation this data would suggest that nutrients may be confined to the arms of the reservoir for much of the growing season.

## Hebgen Reservoir Zooplankton Monitoring

Densities (individuals/liter) of cladoceran and copepod zooplankton in Hebgen Reservoir have been monitored since 2006. Annual temporal trends in abundance show peak densities occurring in late spring and early summer (Figures 48).

Body size of both cladoceran and copepods increased as densities declined. This has been observed in zooplankton populations in several temperate lakes. The warming of the reservoir in early spring typically

triggers a phytoplankton bloom promoting quick growth of the zooplankton community. However, size selective predation on larger cladocerans by fish reduces their abundance and predation shifts to copepods. Reduced predation on the remaining cladoceran community could account for the increase in body size seen in the cladoceran community through summer until densities are such that another predation shift occurs (Hall and Threlkeld 1976).

Utah chub comprise the majority of the fish biomass in Hebgen Reservoir (Figure 42) and may be influencing zooplankton densities through predation. Cladoceran densities in Hebgen also appear to be inversely related to the ratio of adult Utah chub/brown trout (Figure 49).

Studies of Utah chub diet in several western reservoirs have shown zooplankton to be the principle food item for Utah chubs. In Strawberry Reservoir, Utah, Johnson (1988) reported that Utah chub shoreline feeding on zooplankton was detrimental to the survival of young-of-the-year cutthroat and rainbow trout. Similarly, enclosure experiments with Utah chub and kokanee *Oncorhynchus nerka* showed that increased densities of Utah chub reduced zooplankton densities and negatively affected kokanee growth (Teuscher and Lueke 1996).

With mean TSI of 35.6 and 35.8 in 2009 and 2010 respectively 36.3 for the last three years, Hebgen Reservoir is classified as a borderline oligotrophic-mesotrophic lake according to the Trophic State Index developed by Carlson (1977) (Figure 50). This may explain the low densities of plankton observed in monthly plankton tows. Hebgen Reservoir plankton densities relate positively with TSI score (Figure 51).

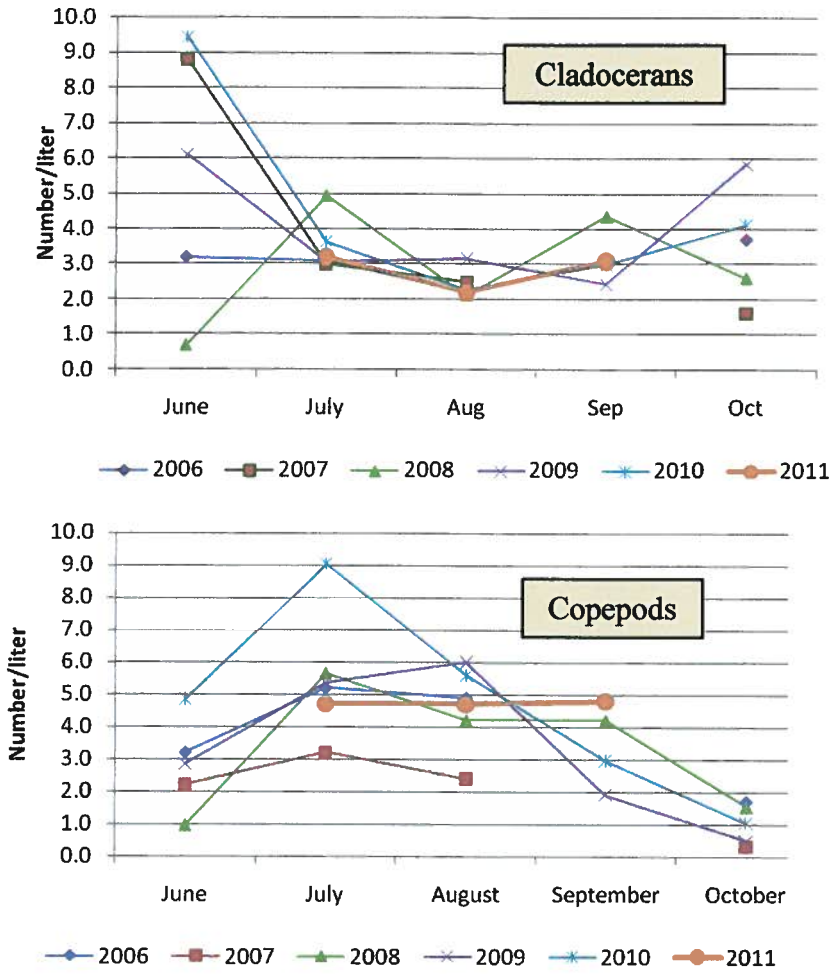


Figure 48. Figure showing cladoceran and copepod densities (individuals/liter) sampled in Hebgen Reservoir by month, 2006-2011.

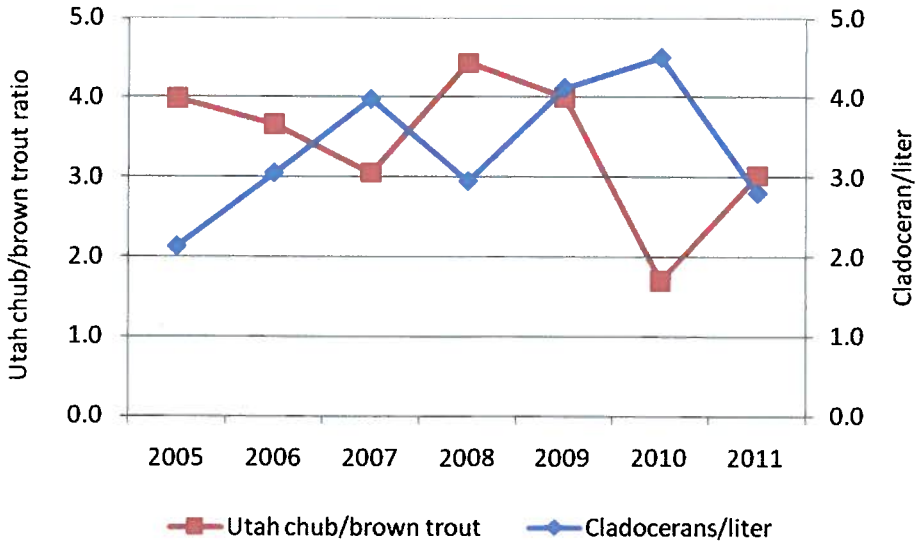


Figure 49. Number of Utah chub per brown trout (calculated from annual spring gillnetting) vs. annual mean cladoceran density in Hebgen Reservoir, 2005 - 2011.

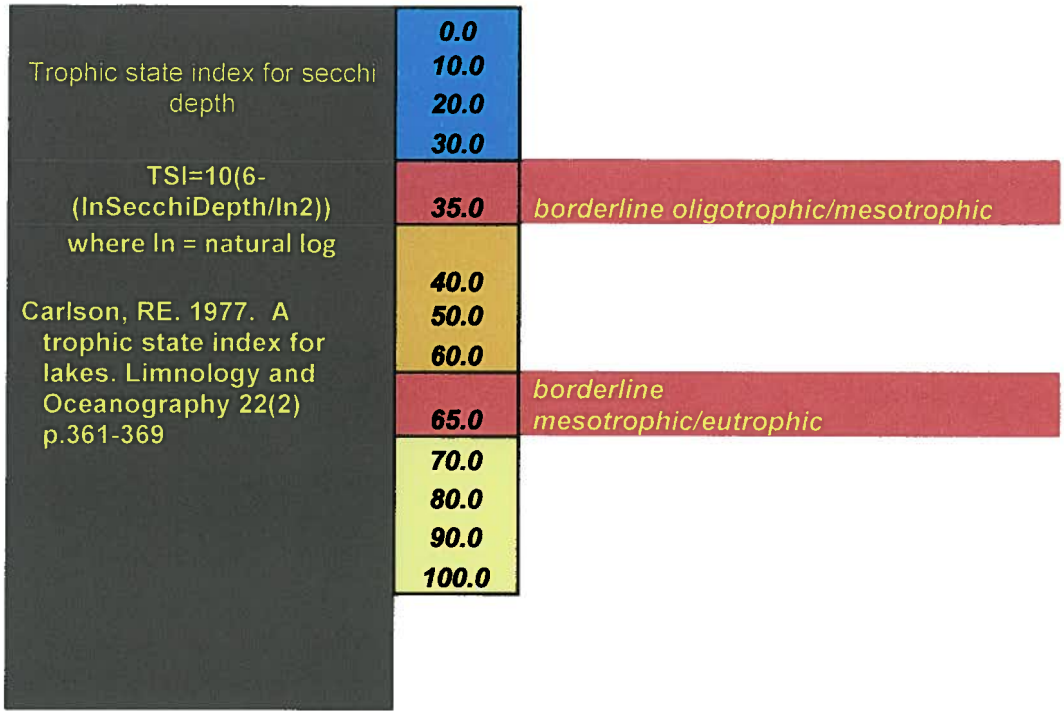


Figure 50. Figure depicting the trophic state index formula and classification for lake productivity using secchi depth measurements.

FWP and PPL Montana incorporated an anemometer into the weather station in 2011 to measure wind direction. Wind direction data (Appendix I) shows that wind patterns predominately occurred out of the southwest in 2011. This raises some interesting questions concerning nutrient cycling through the reservoir as the productive Madison and Grayling arms of Hebgen are oriented east - west along with the less productive main body of the reservoir (Figure 52). Additionally, connectivity of the arms to the main body of the reservoir are narrow which may be functioning as a bottleneck limiting the amount of nutrient exchange between the arms and the main reservoir. A gross comparison of wind data and zooplankton densities at sites seem to be related (Figure 52). Sites located on the northeastern side of the reservoir had higher densities of zooplanktoners in 2011 than sites on the southwestern side of the reservoir. Conversely, wind direction data compared against zooplankton abundance for 2008 and 2009 show an increase in plankton densities at the southern end of the reservoir as wind was predominately out of the northwest during those years. No significant change in densities was observed at sites that were sheltered from wind. This information could be useful in maximizing stocking efficiency by being able to locate hatchery fish to areas of higher food concentrations.

## 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.

Fish population monitoring will continue annually in the Madison River. These data are necessary for setting and reviewing angling regulations, and to monitor environmental and biological impacts on the populations.

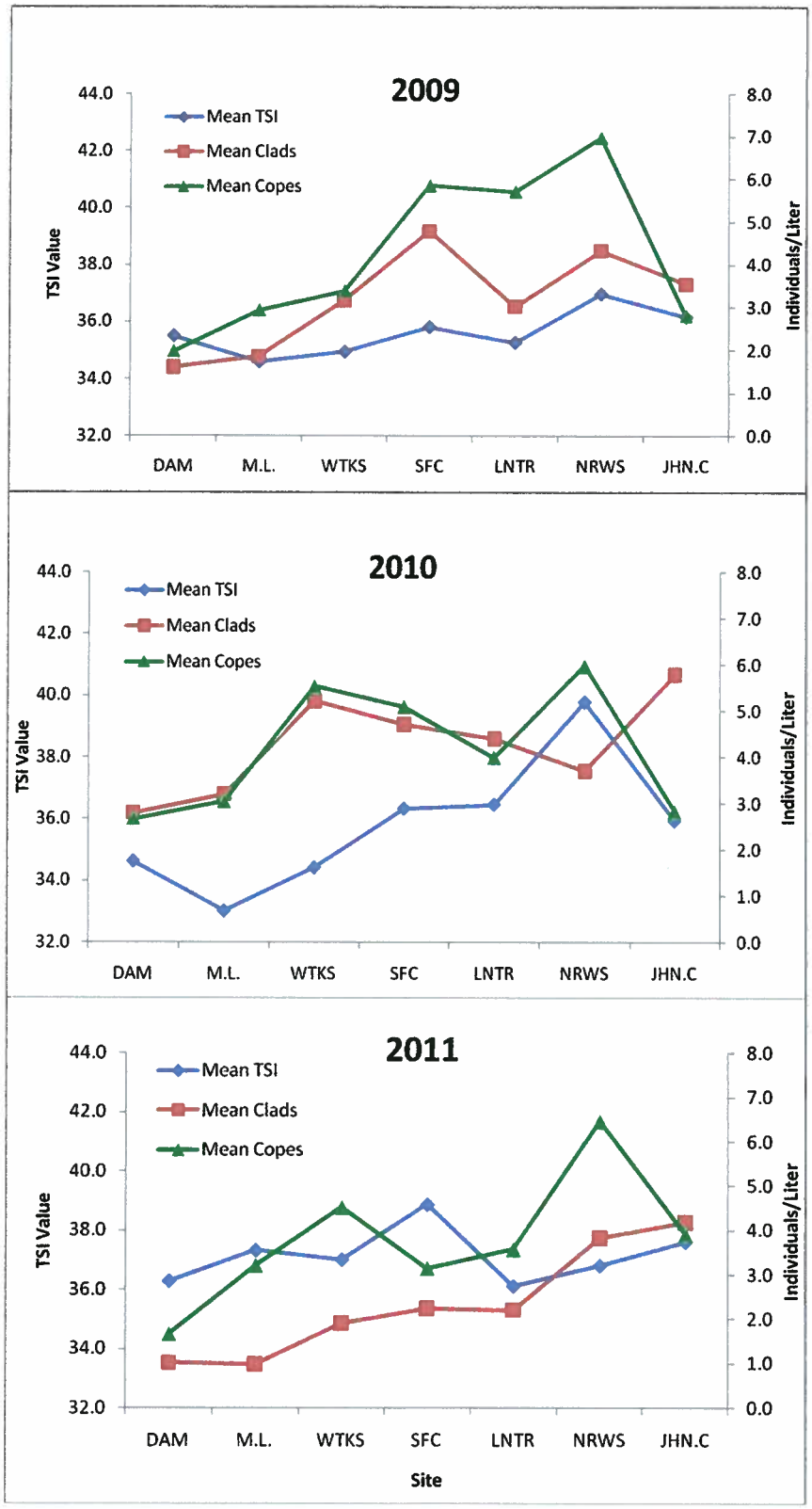


Figure 51. Hebgen Reservoir mean TSI score and mean densities of zooplankton by site, 2009 - 2011. Site names are Dam, Moonlight Bay, Watkins Creek, South Fork Cabin, Lone Tree (Horse Butte), Narrows, and Johnson Creek. Sites are listed in a counterclockwise fashion from the dam (Figure 52).


| Site | 2008 | 2009 | 2011 |
|---|---|---|---|
| **1** Dam | 2.0 | 1.7 | 1.0 |
| **2** Moonlight | 1.9 | 2.0 | 1.0 |
| **3** Watkins | 3.1 | 4.5 | 1.9 |
| **4** S. Fork Cabin | 3.5 | 4.8 | 2.2 |
| **5** Horse Butte | 3.5 | 3.9 | 2.2 |
| **6** Narrows | 4.1 | 4.9 | 3.8 |
| **7** Johnson Ck. | 2.6 | 4.3 | 3.1 |

Figure 52. Prevailing wind direction and mean zooplankton densities per site for 2008, 2009 and 2011. Wind data are not available for 2010.

Monitoring of the fish response to habitat improvement projects on Jack, Watkins and the South Fork of Meadow Creek will continue in 2012, as well as alternate year monitoring on sections of the O'Dell Creek wetland restoration project.

Aquatic Invasive Species monitoring will continue through the 2188 Biological and Biocontaminant monitoring program and through the FWP Aquatic Nuisance Species Program.

Rainbow trout captive stock used in Whirling Disease sentinel cage studies in the Madison River have continued to show high infection rates and severity. In laboratory studies, progeny of Madison River rainbow trout exhibited lower infection severity to whirling disease when compared to hatchery stock rainbow trout.

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

In 2011, WCT from the Sun Ranch Brood provided fry for the Cherry Creek project and introduction back into the Sun Ranch Brood. Additionally, fertilized eggs from three wild donor populations were reared in the Sun Ranch Hatchery and introduced into recipient streams as eyed eggs or fry, and resulting fry from one of those wild donor populations was also introduced into the Sun Ranch Brood.

No piscicides were applied in Cherry Creek in 2011. Introductions of WCT continued in Phase 3 and in Cherry Lake. Introductions are scheduled to continue into 2012 and 2013. Wide spread monitoring was conducted throughout the project area in 2011 and is expected to continue for several more years.

Activation of the well and delivery system allows permanent removal of tarps and a portion of a hand-built rock dam in Lake Creek, providing year-round passage for spawning brown trout and other aquatic species. Installation of the waterline from the well drilled in 2009 to stock tanks was completed in 2010. Brown trout were documented upstream of the rock dam in 2011.

The proportion of the Hebgen Reservoir rainbow trout gillnet catch larger than 14 inches has increased since 2003.

Cladoceran and copepod zooplankton densities in Hebgen Reservoir showed diverse abundance patterns. Cladoceran density tends to be at its highest in June while copepod density peaks in July.

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Appendix A1

Summary of Ennis Reservoir beach seining 1995 - 2010

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 |
| 9/29/08 | 0 | 0 | 3 | 1 |
| 10/1/09 | 0 | 0 | 139 | 30 |
| 10/22/09 | 1 | 5 | 0 | 0 |
| 10/6/10 | 0 | 0 | 1 | 0 |
| 10/3/11 | 0 | 4 | 9 | 5 |

Appendix A2

Description of young-of-the-year Arctic grayling beach seining locations in Ennis Reservoir, and catch at each site. See Figure 4 for site locations.

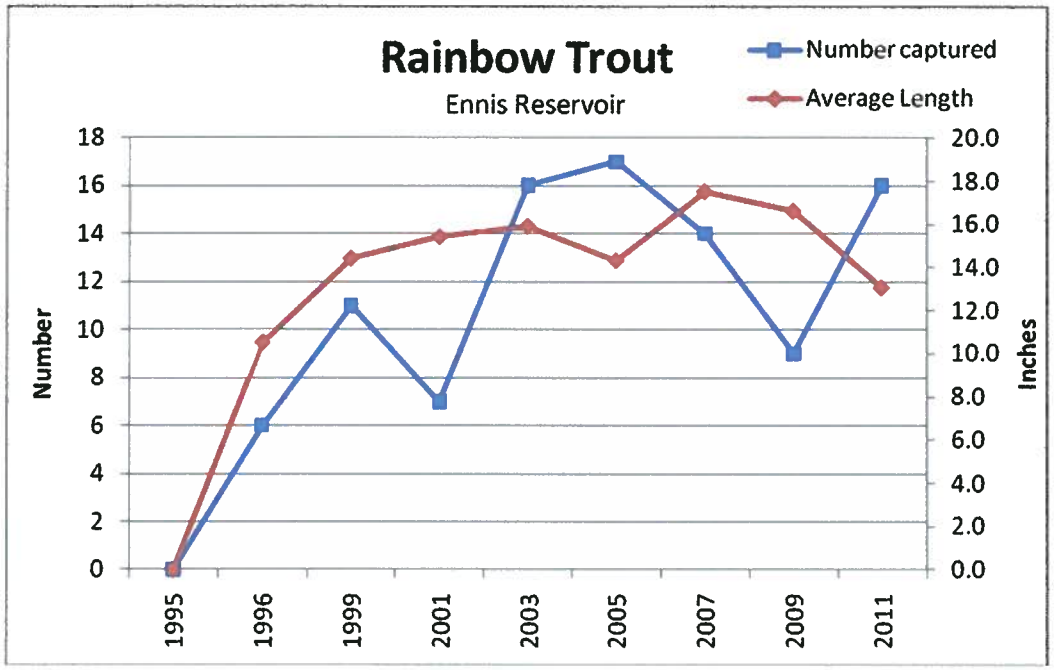
Species abbreviations:

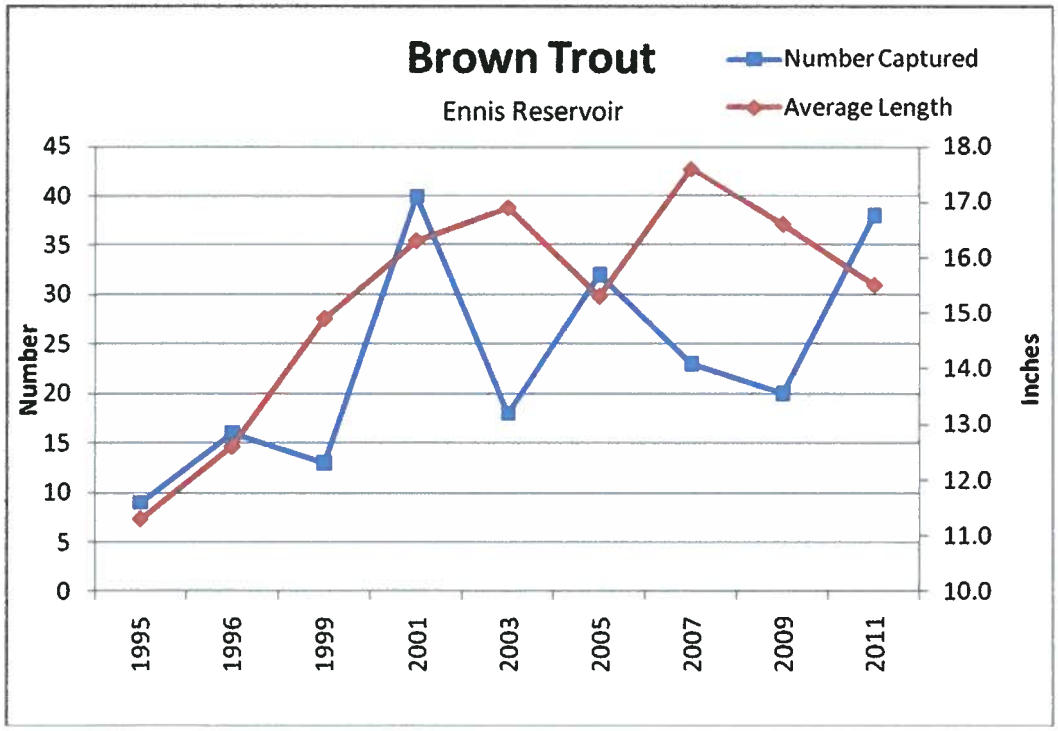
| | |
|---|---|
| AG | Arctic grayling |
| MWF | mountain whitefish |
| Rb | rainbow trout |
| LL | brown trout |
| WSu | white sucker |
| UC | Utah chub |
| LND | long-nose dace |
| Sc | Rocky Mountain (mottled) sculpin |
| FhM | Fathead Minnow |

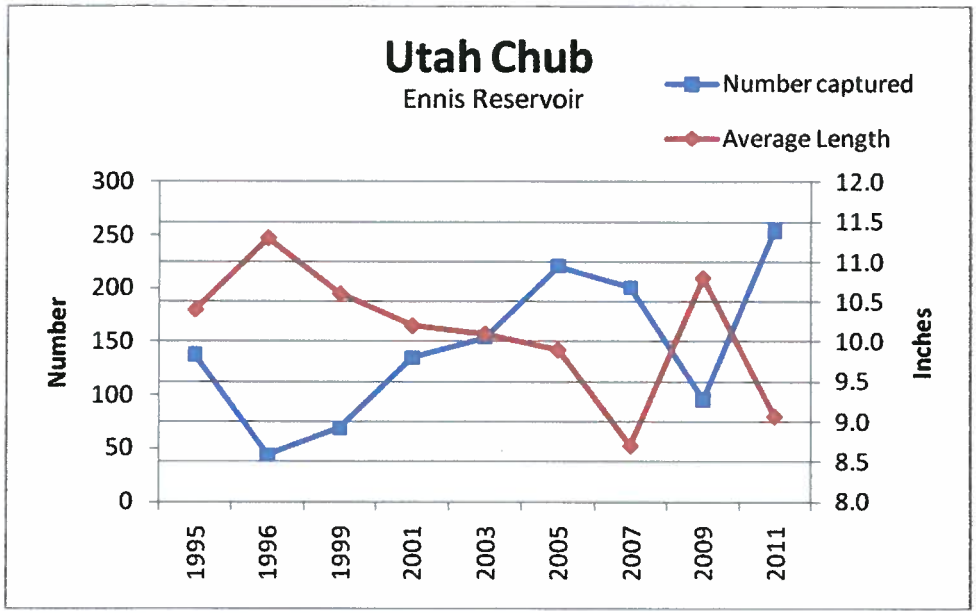
| Site | AG | MWF | Note |
|---|---|---|---|
| South shore east of river mouth<br>10/3/11<br>Fig 4 site 1 | 0 | 0 | Macrophytes dense<br>249 juv. WSu<br>5 juv. UC<br>36 LND<br>3 Sc |
| South shore btwn river & Fletcher's<br>10/3/11<br>Fig 4 site 2 | 0 | 0 | Macrophytes dense<br>369 juv. WSu<br>17 juv. UC<br>3 y-o-y Rb<br>3 LND |
| Southwest shore west of Fletcher's mouth<br>10/3/11<br>Fig 4 site 3 | 0 | 0 | Macrophytes sparse<br>160 juv. WSu<br>10 juv. UC<br>20 LND<br>1 Sc |
| Meadow Ck FAS north shore willows<br>10/3/11<br>Fig 4 site 4 | 0 | 0 | Macrophytes dense<br>1 Rb 19.4"<br>8 LL 2.8' – 16.9"<br>133 juv. WSu<br>124 juv. UC<br>147 LND<br>2 Sc<br>2 FhM |
| Meadow Ck FAS south of Meadow Ck mouth<br>10/3/11<br>Fig 4 site 4 | 0 | 4 | Macrophytes sparse<br>1 Rb 4.5"<br>1 LL 7.6"<br>4 y-o-y MWF 4.2" – 5.4"<br>92 juv. WSu<br>2 juv. UC<br>1 LND |

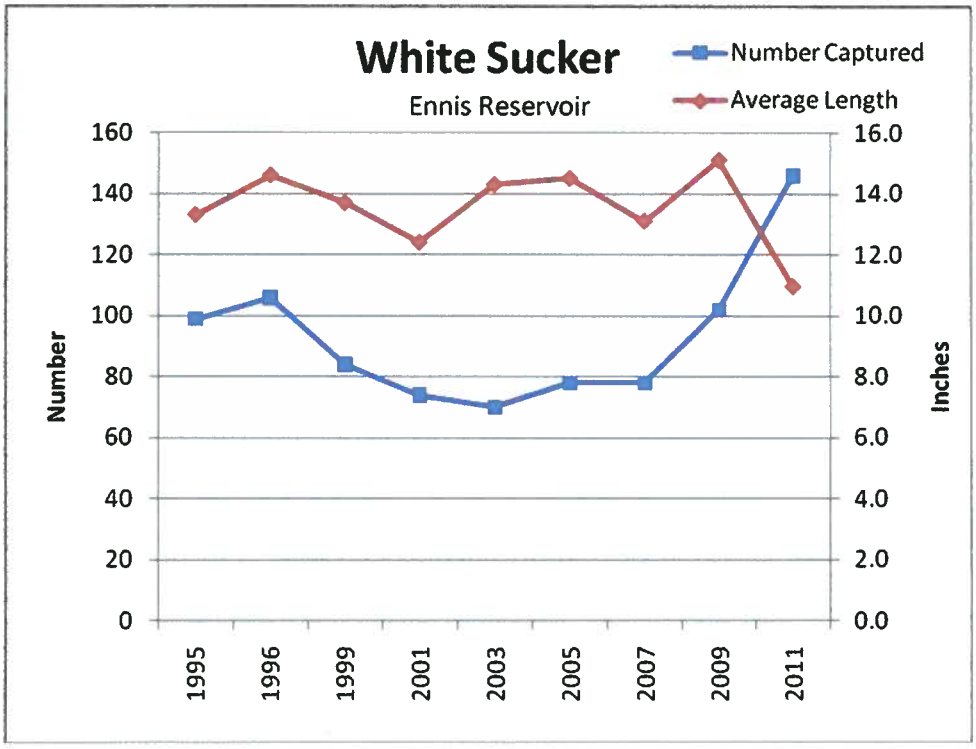
Appendix A3

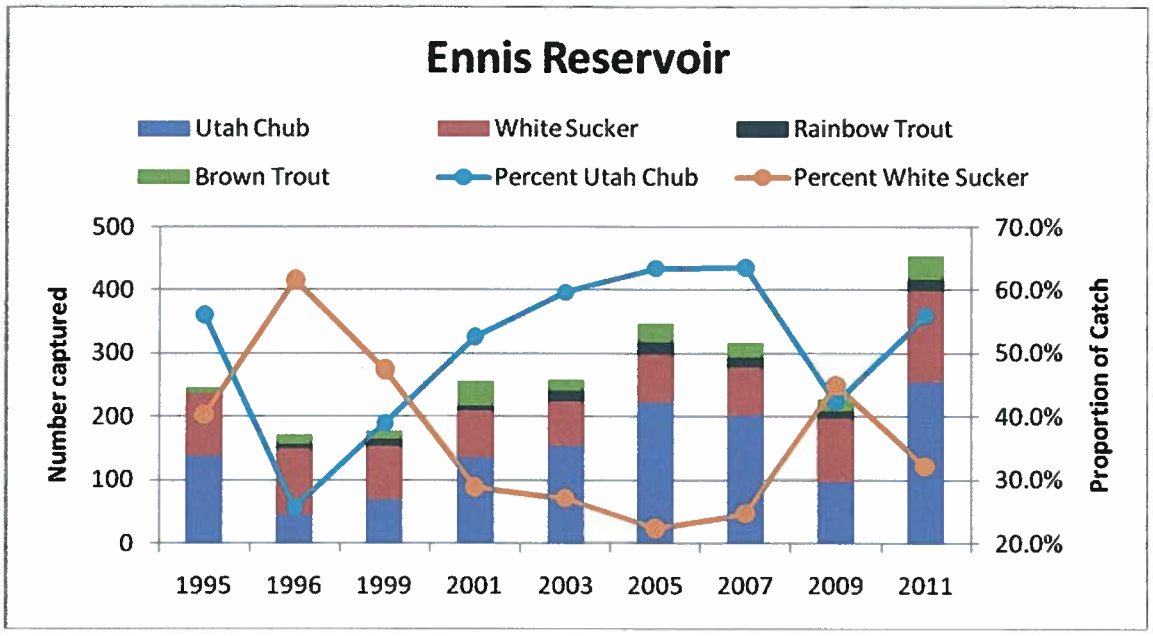
Ennis Reservoir Gillnet Trend
1995 – 2011
No whitefish have been captured in Ennis Reservoir gillnetting since 1999




Utah Chub
Ennis Reservoir
Number captured
Average Length
Number
Inches
300
250
200
150
100
50
0
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
1995
1996
1999
2001
2003
2005
2007
2009
2011


White Sucker
Ennis Reservoir
Number Captured
Average Length
Number
Inches
160
140
120
100
80
60
40
20
0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
1995
1996
1999
2001
2003
2005
2007
2009
2011


Ennis Reservoir
Utah Chub
White Sucker
Rainbow Trout
Brown Trout
Percent Utah Chub
Percent White Sucker
Number captured
Proportion of Catch
500
400
300
200
100
0
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
1995
1996
1999
2001
2003
2005
2007
2009
2011

Appendix B

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 mud snails, 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 Mud Snails has been completed. All state, federal and private hatcheries have been inspected for New Zealand mud snails. One private hatchery contains New Zealand mud snails, strategies have been implemented to prevent the spread of this invasive through hatchery operations. The spread of New Zealand mud snails 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 mud snails. 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 100$^{th}$ 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".


INSPECT. CLEAN. DRY.

**With just three easy steps, you can do your part to help stop the spread of aquatic invasive species like plants, mussels and whirling disease:**

# INSPECT.
# CLEAN.
# DRY.

## 1. INSPECT.

After leaving a lake or stream, inspect your boat, engine, trailer, anchor, waders, and other fishing and boating gear for mud, water, and vegetation that could carry aquatic invasive species.

## 2. CLEAN.

Completely remove all mud, water, and vegetation you find. Boaters should use a pressurized power sprayer, found at most do-it-yourself car washes. The hot water helps kill organisms and the pressure removes mud and vegetation. No need to use soap or chemicals.

## 3. DRY.

Aquatic invaders can survive only in water and wet areas. By draining and drying your boat and fishing equipment thoroughly, you will kill most invasive species. The longer you keep your boat, trailer, waders, and other equipment outside in the hot sun between fishing trips, the better.

A message brought to you in partnership by
Montana Fish, Wildlife & Parks and the Montana Department of Agriculture

MONTANA DEPARTMENT OF AGRICULTURE

Montana Fish, Wildlife & Parks

**MAKE THE CALL:** Report violations anonymously to 1-800-TIP-MONT

**STOP AQUATIC HITCHHIKERS!**

Appendix C

2011 Monitoring Reports

Gallatin National Forest
Hebgen Ranger District: Watkins Creek

Project Title: **Watkins Creek Large Woody Debris Placement (December 2008 Proposal, September 2010 Implementation)**

Which PM&E measure(s) in the Project 2188 License will this proposal enhance or support?

408-3 Fish habitat enhancement both in main stem and tributary streams, including enhancement for all life stages of fishes.

Report by: **Bruce Roberts**

Location of Proposed Project: **Watkins Creek**

## INTRODUCTION

Watkins Creek is presently a lightly used spawning tributary to Hebgen Lake for various reasons including: low late-season stream flows, partial barrier culvert across FS Road # 167 (East Denny Creek Road), and high sediment levels (Watschke, 2006). The Forest Service is in the process of replacing the existing culvert along the East Denny Creek Road with a bridge. Montana Trout Unlimited has discussed leasing water rights options along lower Watkins Creek to improve late-season stream flows. Together, it is anticipated that Watkins Creek will soon harbor a larger adfluvial run of spawning rainbow and brown trout.

Approximately two miles upstream of Hebgen Lake is a quarter mile reach of stream mostly devoid of instream Large Woody Debris (LWD) (Pictures 1, 2, and 3). Very few high quality pools exist within this reach; streambed is dominated by larger non-suitable spawning substrate; and, unvegetated stream banks beneath this dense stand are eroding. This healthy dense stand of spruce shows little sign of increased naturally occurring LWD recruitment in the near future. The Forest Service proposed to drop 40-50 spruce trees into Watkins Creek at 15-20 sites to meet intended objectives. The primary objective was to increase recruitment of wild juvenile trout both in Watkins Creek and Hebgen Lake by sorting and trapping spawning gravels. Secondary objectives were to increase: 1) trapping of fine sediments; 2) creation of high quality scour and dammed pools; and, 3) sunlight penetration to the valley floor increasing herbaceous and deciduous vegetation plants.

Funding for this project was approved at the December 2008 MADTAC meeting. Issues that arose as a result of the project being planned within the Lionshead Inventoried Roadless Area (IRA) caused the project to be delayed by one field season.

## METHODS

A Forest Service saw crew directionally fell approximately 60 spruce and lodgepole trees (primarily spruce) along the main channel and adjacent high water side channel to artificially increase LWD recruitment. It was attempted to space these LWD jams every 7 to10 bankful widths. The project was implemented on September 29, 2010. The project was laid out by Scott Barndt (Gallatin National Forest fish program manager), Bruce Roberts (Gallatin National Forest west zone fisheries biologist), and Jim Hanson (Gallatin National Forest fire engine foreman and lead chain saw trainer/certifier). The two project biologists picked the sites and chain saw operator helped identify which trees he could safely drop to meet project objectives. The intent was to mimic naturally occurring LWD jams located immediately upstream. Two or three smaller trees were identified to be dropped first at a specific location followed by a much larger tree that would pin down or anchor everything together. Trees were cut far enough away from the highwater mark to maintain channel stability and to insure cut logs were adequately entangled with standing trees to prevent downstream movement of downed LWD.

Trees were not jockeyed around into position using come-a-longs, pulleys, or other mechanical devices; where they landed is where they stayed.

To monitor project success, Montana Fish, Wildlife and Parks conducted a pre-population survey during the summer of 2010. The Forest Service measured habitat attributes such as residual pool depth along the thalweg and estimated the amount of spawning substrate immediately upstream and/or downstream of each structure or LWD jam. Measuring residual pool depth would determine how much scouring actually took place associated with each structure. Spawning substrate estimates would determine how spawning substrate was sorted and trapped. These data will be remeasured post-project to evaluate the effectiveness of the treatment after a couple highwater events. Maximum depth (m) and tail crest depth (m) measurements used to calculate residual pool depth were measured along the thalweg in areas where the crew felt these depths would occur after subsequent highwater events.

## RESULTS

A total of 19 LWD jams were created using 60 trees ranging in size from 6" to 24" diameter breast height Seventeen LWD jams were created along the main-channel of Watkins Creek (Pictures 4 and 5) and two along a high water side-channel adjacent to Watkins Creek. Only four of the seventeen main-channel sites had existing spawning substrate within the area either immediately upstream and/or downstream. One of the four sites with existing spawning substrate was an existing LWD jam that we added additional pieces to so the scour and gravel sorting and trapping had previously occurred.

**Table 1.** Habitat attributes measured at 17 main channel sites previous to any high water events.

| Treatment No. | Treatment Location | Maximum Depth (m) | Tail Crest Depth (m) | Residual Pool Depth (m) | Spawning Substrate ($m^2$) | |
|---|---|---|---|---|---|---|
| | | | | | Above | Below |
| 1 (top) | Main | 0.45/[a] | 0.23 | 0.22 | 0.0 | 4.0 |
| 2 | Main | 0.25 | 0.25 | 0.00 | 0.0 | 0.0 |
| 3 | Main | 0.25 | 0.20 | 0.05 | 0.0 | 0.0 |
| 4 | Main | 0.26 | 0.25 | 0.01 | 0.0 | 0.0 |
| 5 | Side | | | | | |
| 6 | Main | 0.35 | 0.20 | 0.15 | 0.0 | 0.0 |
| 7 | Side | | | | | |
| 8 | Main | 0.40 | 0.28 | 0.12 | 36.5 | 0.0 |
| 9 | Main | 0.31 | 0.23 | 0.08 | 0.0 | 0.0 |
| 10 | Main | 0.26 | 0.20 | 0.06 | 0.0 | 9.0 |
| 11 | Main | 0.23 | 0.24 | -0.01 | 0.0 | 0.0 |
| 12 | Main | 0.21 | 0.25 | -0.04 | 0.0 | 0.0 |
| 13 | Main | 0.20 | 0.21 | -0.01 | 0.0 | 0.0 |
| 14 | Main | 0.19 | 0.16 | 0.03 | 0.0 | 0.0 |
| 15 | Main | 0.25 | 0.15 | 0.10 | 5.0 | 1.5 |
| 16 | Main | 0.30 | 0.31 | -0.01 | 0.0 | 0.0 |
| 17 | Main | 0.26 | 0.24 | 0.02 | 0.0 | 0.0 |
| 18 | Main | 0.30 | 0.25 | 0.05 | 0.0 | 0.0 |
| 19 (bottom) | Main | 0.14 | 0.15 | -0.01 | 0.0 | 0.0 |

/[a] = Treatment Site 1 was an existing LWD jam that was augmented with additional LWD pieces, so scouring and substrate accumulation had previously occurred.

**Pictures 1 and 2** – Pre-LWD recruitment condition along the proposed treatment reach of Watkins Creek.

**Pictures 3 and 4** – Pre- and Post-treatment looking upstream at Site 18 along Watkins Creek.

**Picture 5** – Post-treatment looking upstream at Site 19 along Watkins Creek.

# Appendix D

## Statistics of Madison River radio transmittered rainbow trout, 2010 – 2011

| Code | Implant Date | Implant Location | Length | Weight | gender | 2010 miles moved | 2011 miles moved from end of 2010 |
|---|---|---|---|---|---|---|---|
| 11 | 9/23/2009 | RM 52.3 | 15.9 | 1.36 | U | -12.3 | <0.2 |
| 12 | 9/23/2009 | RM 52.3 | 17.2 | 1.81 | U | -8.2 | <0.2 |
| 13 | 9/23/2009 | RM 52.3 | 17.0 | 1.90 | U | -11.8 | -0.6 |
| 14 | 9/23/2009 | RM 52.3 | 16.2 | 1.77 | Rp M* | -7.8 | NA |
| 15 | 9/23/2009 | RM 52.3 | 16.1 | 1.53 | U | 1.1 | NA |
| 16 | 9/23/2009 | RM 52.3 | 14.8 | 1.22 | U | 5.4 | NA |
| 17 | 9/23/2009 | RM 52.3 | 15.1 | 1.49 | U | <0.2 | NA |
| 18 | 9/23/2009 | RM 52.3 | 15.0 | 1.42 | U | -6.1 | <0.2 |
| 19 | 9/23/2009 | RM 52.3 | 15.3 | 1.49 | U | -2.3 | <0.2 |
| 20 | 9/24/2009 | RM 55.8 | 14.5 | 1.19 | U | 0.7 | NA |
| 21 | 9/24/2009 | RM 55.8 | 14.6 | 1.05 | U | NA | NA |
| 22 | 9/24/2009 | RM 55.8 | 16.9 | 1.39 | U | -1.2 | NA |
| 23 | 9/24/2009 | RM 55.8 | 14.6 | 1.04 | U | -1.1 | NA |
| 24 | 9/24/2009 | RM 55.8 | 20.0 | 2.58 | U | -5.8 | NA |
| 25 | 9/24/2009 | RM 55.8 | 17.0 | 1.73 | U | NA | NA |
| 26 | 9/24/2009 | RM 55.8 | 20.0 | 3.13 | U | -11.5 | NA |
| 27 | 9/24/2009 | RM 55.8 | 15.5 | 1.32 | U | 3.7 | -2.5 |
| 28 | 9/24/2009 | RM 55.8 | 13.5 | 0.89 | U | <0.2 | 1.0 |
| 29 | 9/21/2009 | RM 85.9 | 17.2 | 1.55 | U | -1.7 | -0.7 |
| 30 | 9/21/2009 | RM 85.9 | 17.0 | 2.04 | U | 0.5 | <0.2 |
| 31 | 9/21/2009 | RM 85.4 | 18.5 | 2.26 | U | 0.5 | NA |
| 32 | 9/21/2009 | RM 85.4 | 14.7 | 1.38 | U | -11.8 | <0.2 |
| 33 | 9/21/2009 | RM 85.4 | 16.5 | 1.69 | U | 0.5 | <0.2 |
| 34 | 9/21/2009 | RM 85.4 | 15.0 | 1.34 | U | -1.0 | <0.2 |
| 35 | 9/22/2009 | RM 86.4 | 15.2 | 1.20 | U | -0.5 | <0.2 |
| 36 | 9/22/2009 | RM 86.4 | 17.1 | 1.75 | U | -8.9 | -20.7 |
| 37 | 9/22/2009 | RM 86.4 | 15.9 | 1.38 | U | <0.2 | NA |
| 38 | 9/15/2009 | RM 88.8 | 14.0 | 1.00 | U | 1.0 | NA |
| 39 | 9/15/2009 | RM 88.8 | 13.8 | 1.01 | U | 1.2 | NA |
| 40 | 9/15/2009 | RM 88.8 | 15.5 | 1.20 | U | <0.2 | <0.2 |
| 41 | 9/15/2009 | RM 88.3 | 14.3 | 0.96 | U | <0.2 | <0.2 |
| 42 | 9/15/2009 | RM 88.3 | 15.0 | 1.17 | U | -15.1 | <0.2 |
| 43 | 9/16/2009 | RM 88.3 | 14.5 | 0.98 | U | 1.7 | NA |
| 44 | 9/16/2009 | RM 88.3 | 14.6 | 1.08 | U | -14.7 | 0.3 |
| 45 | 9/16/2009 | RM 88.3 | 15.5 | 1.30 | U | <0.2 | NA |

NA = not located or transmitter recovered
* = yes, a ripe male rainbow trout in September

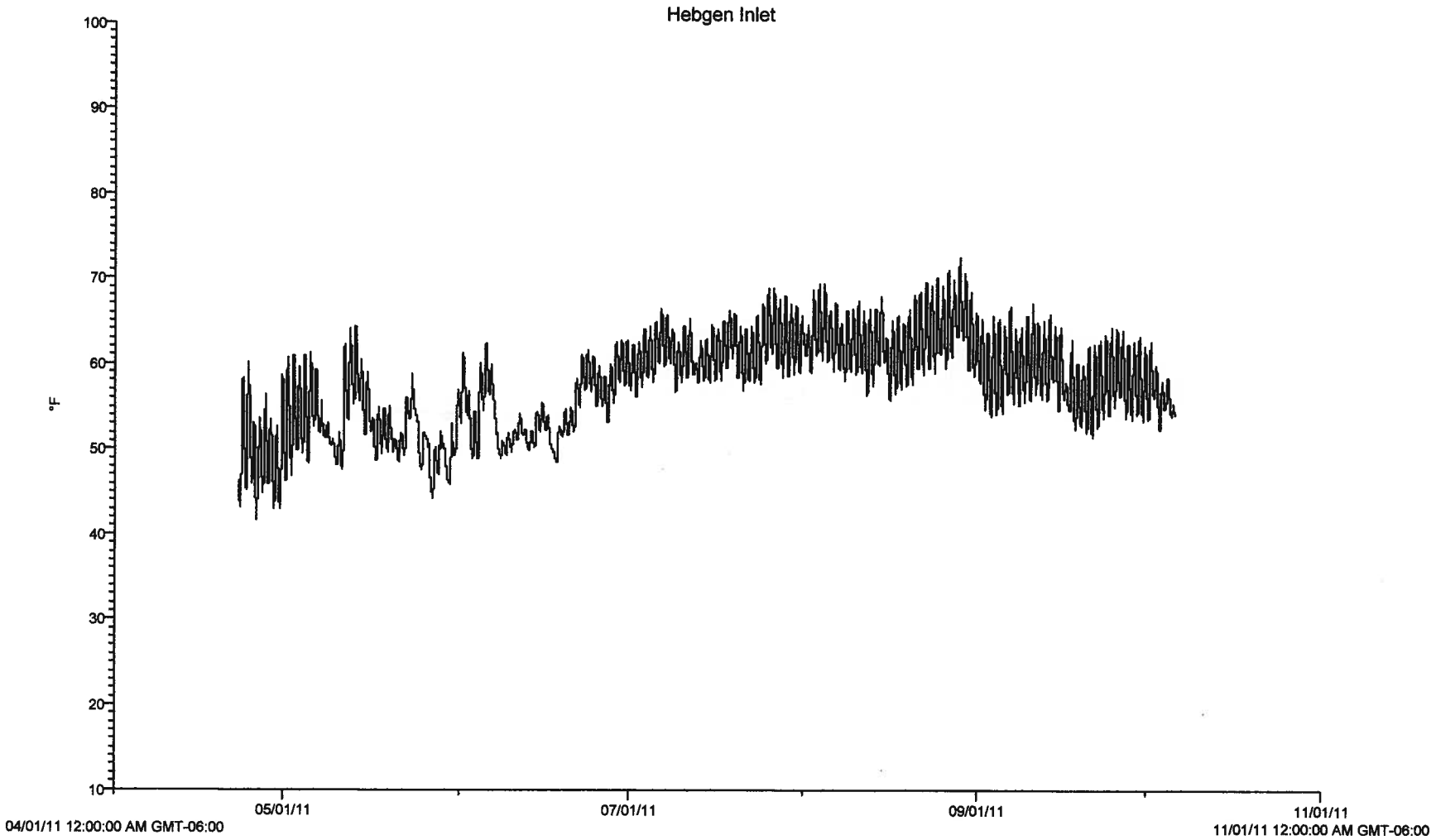
Appendix E1

Temperature recordings from Madison River monitoring sites
2011
See Figure 7 for locations

NOTES:

- Recorders at Hebgen discharge & Headwaters State Park were not recovered

- Maximum temperature at Ennis air was 105.4, but the recorder had been exposed to full sun with a reflective metal background for a period of time. According to National Weather Service, the max air temp in Ennis was 94°F on August 28.


Hebgen Inlet
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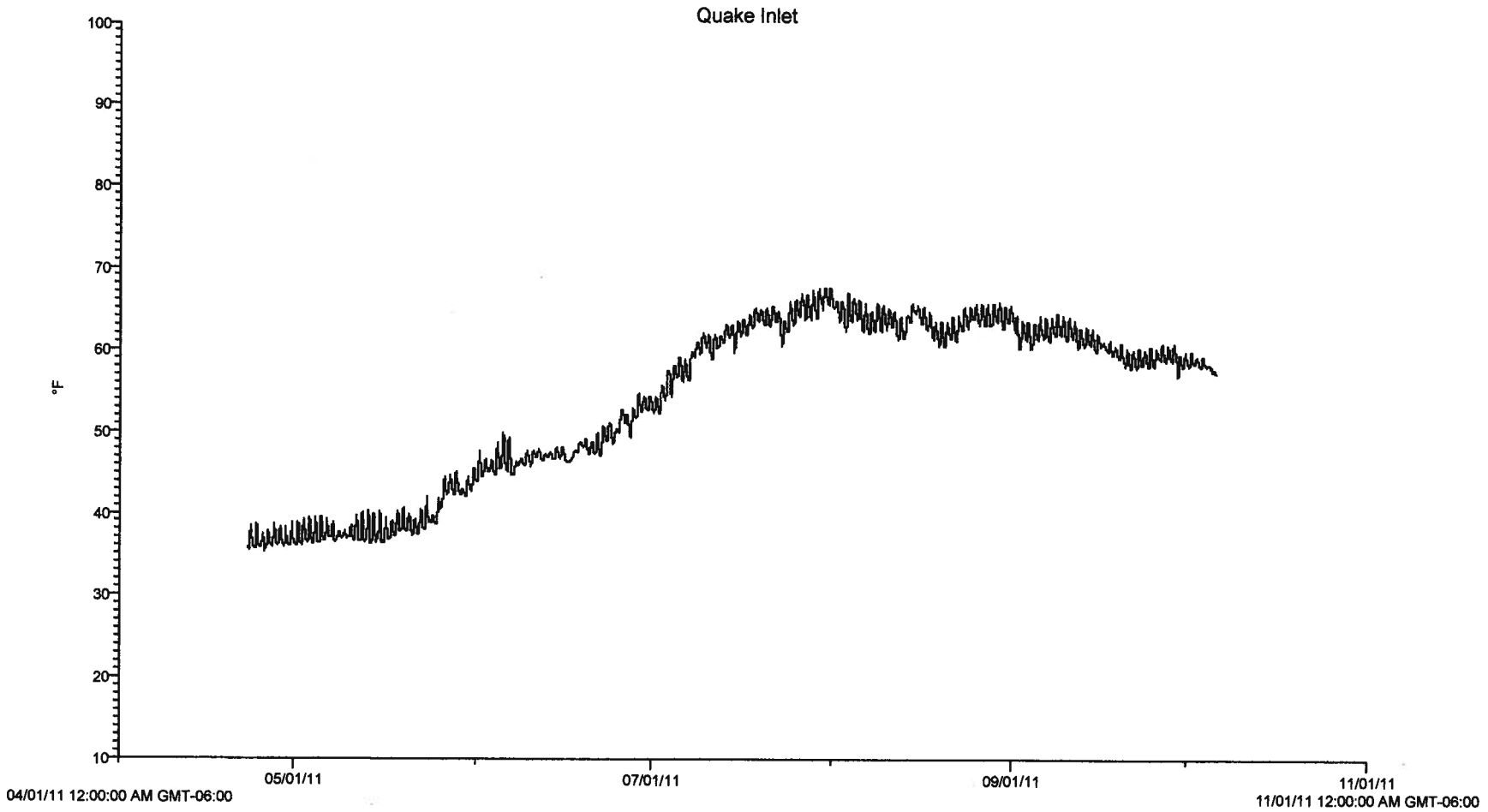
Quake Inlet
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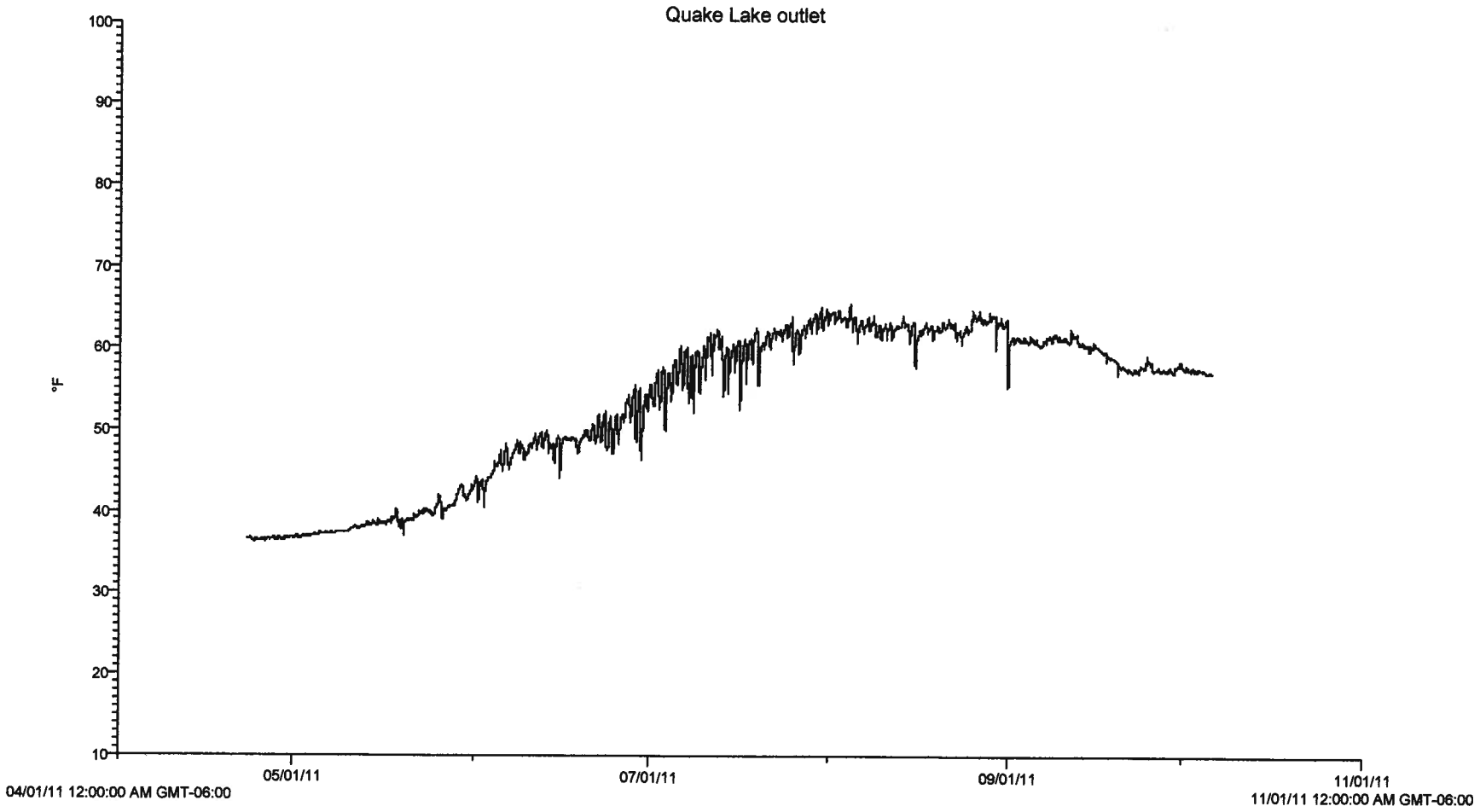
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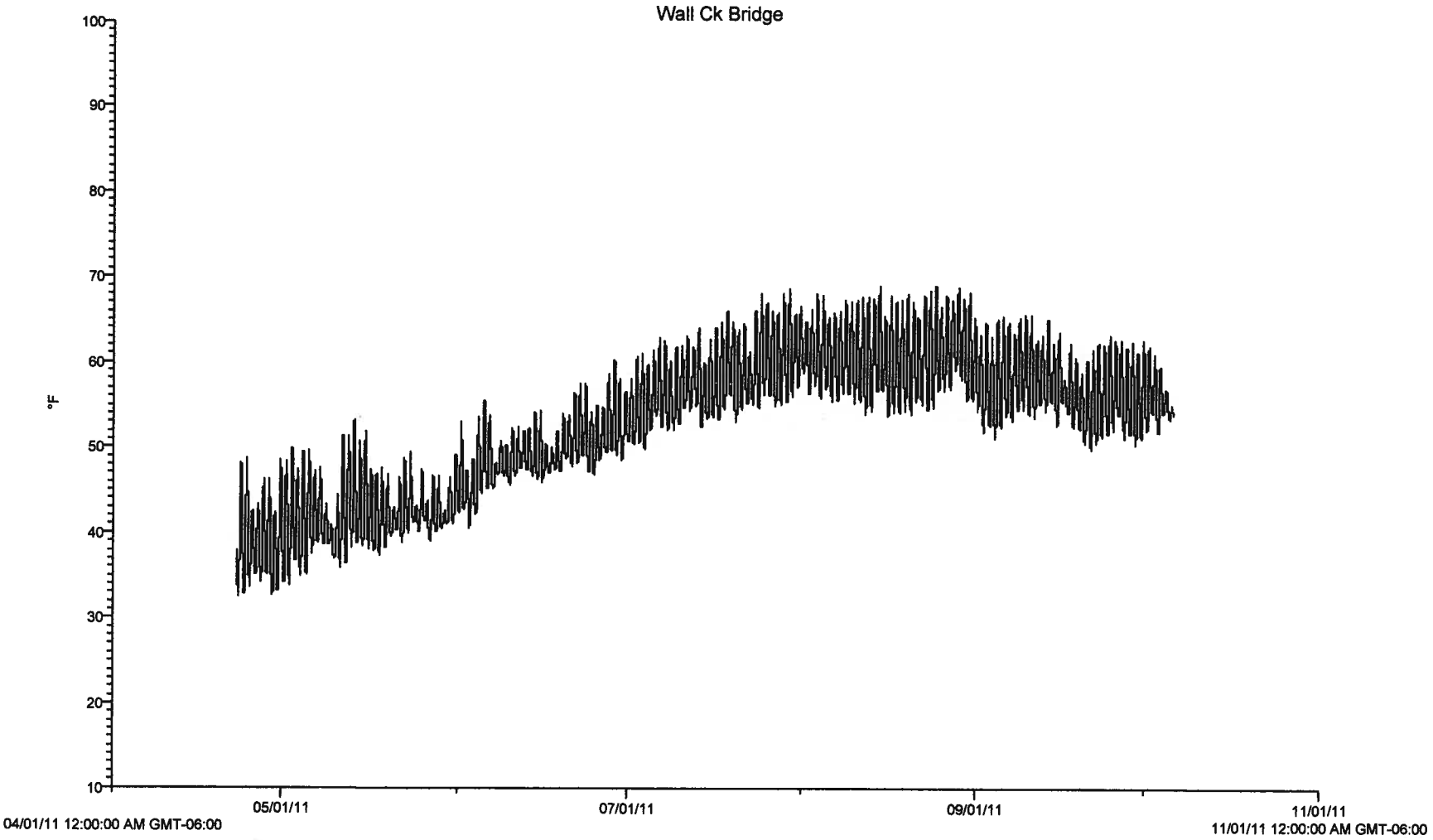
Wall Ck Bridge
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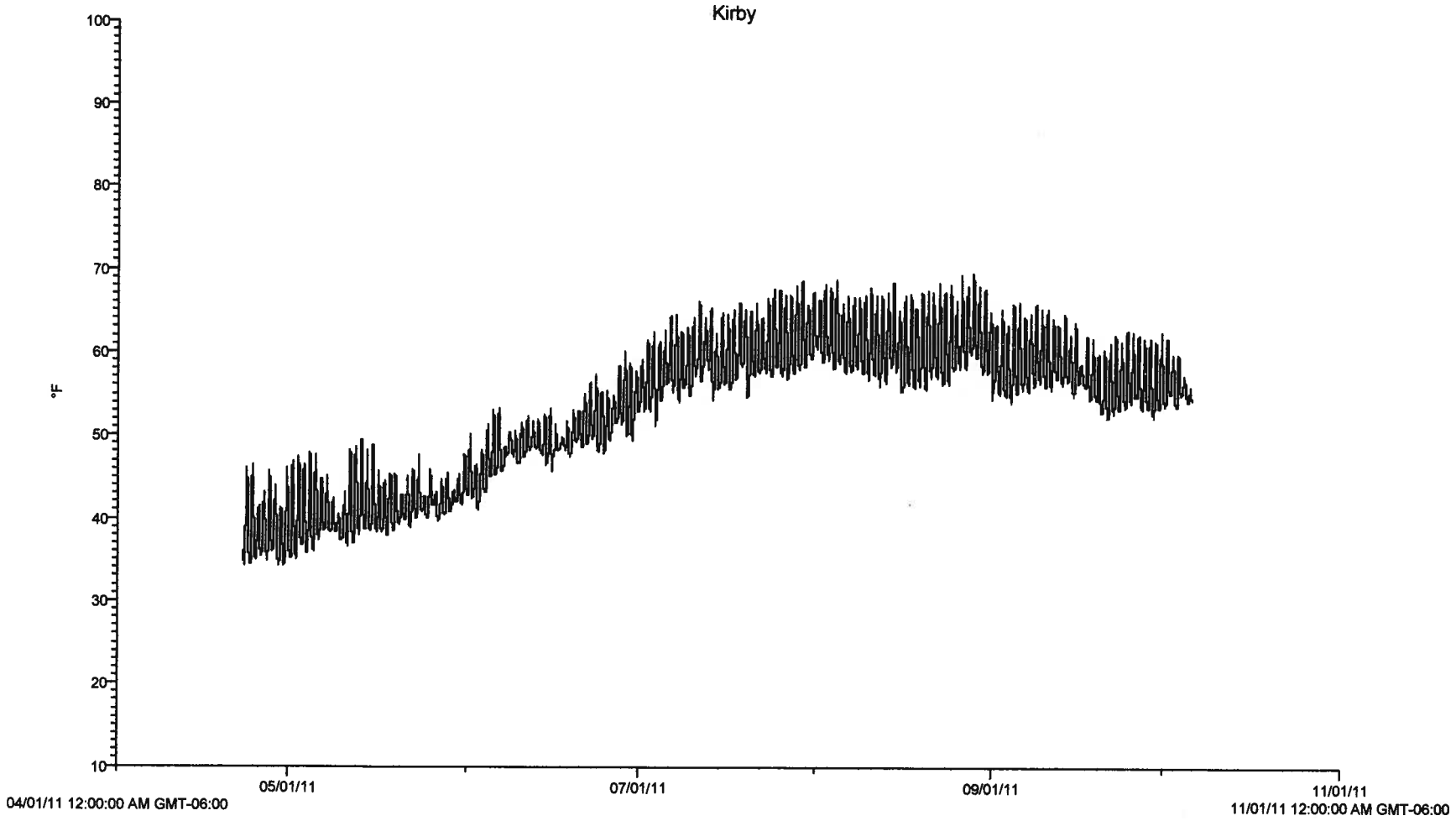
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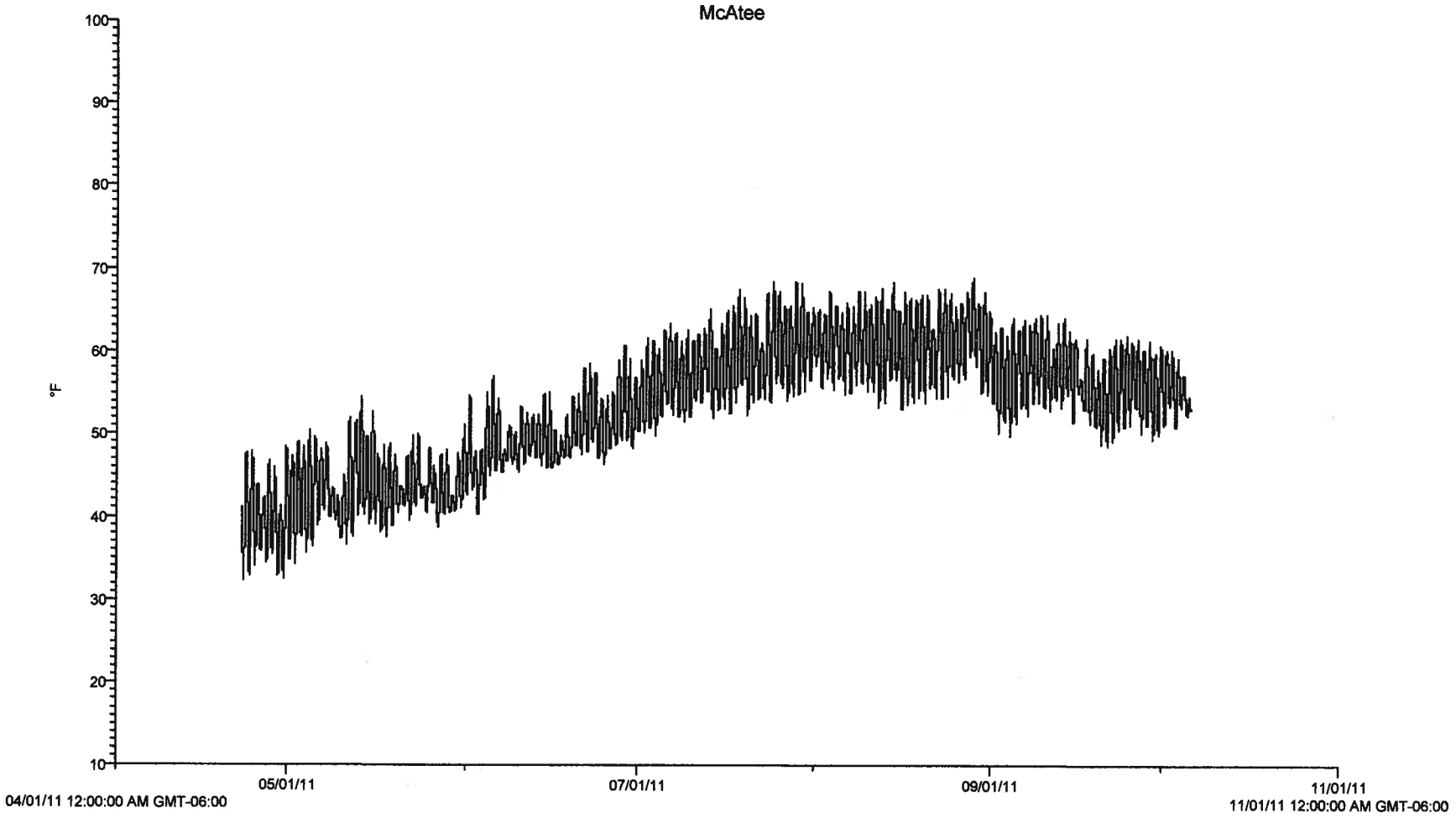
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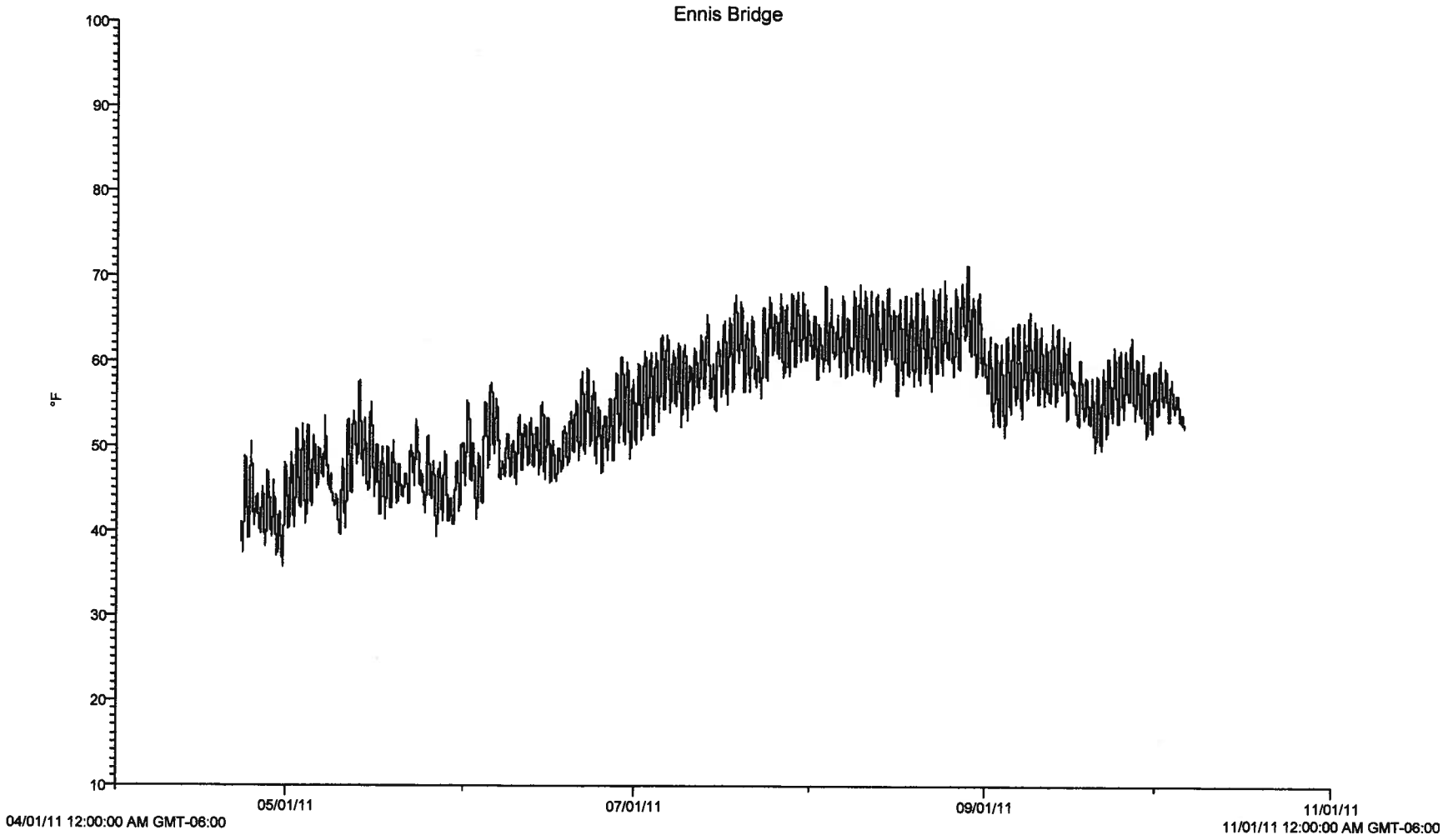
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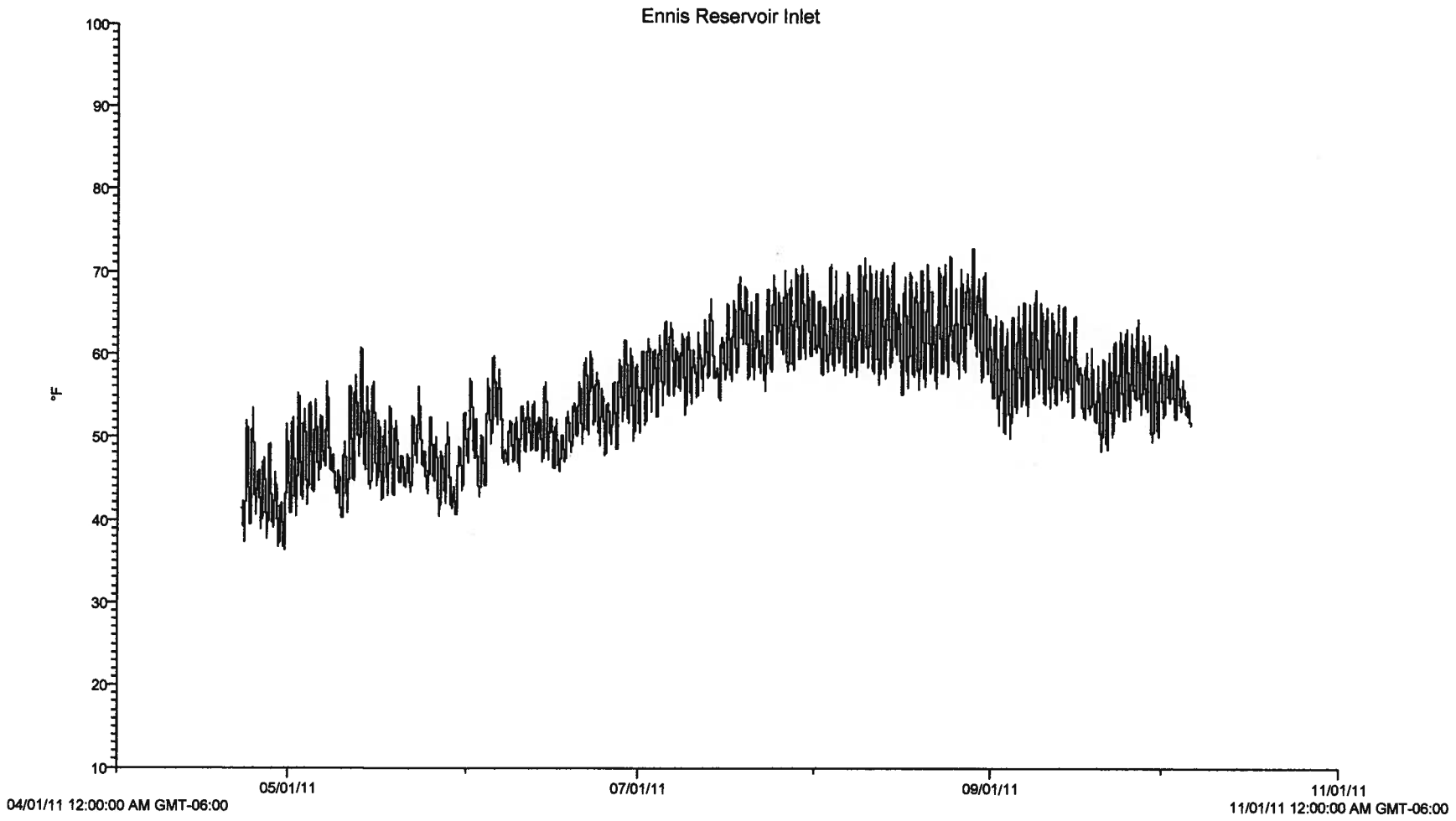
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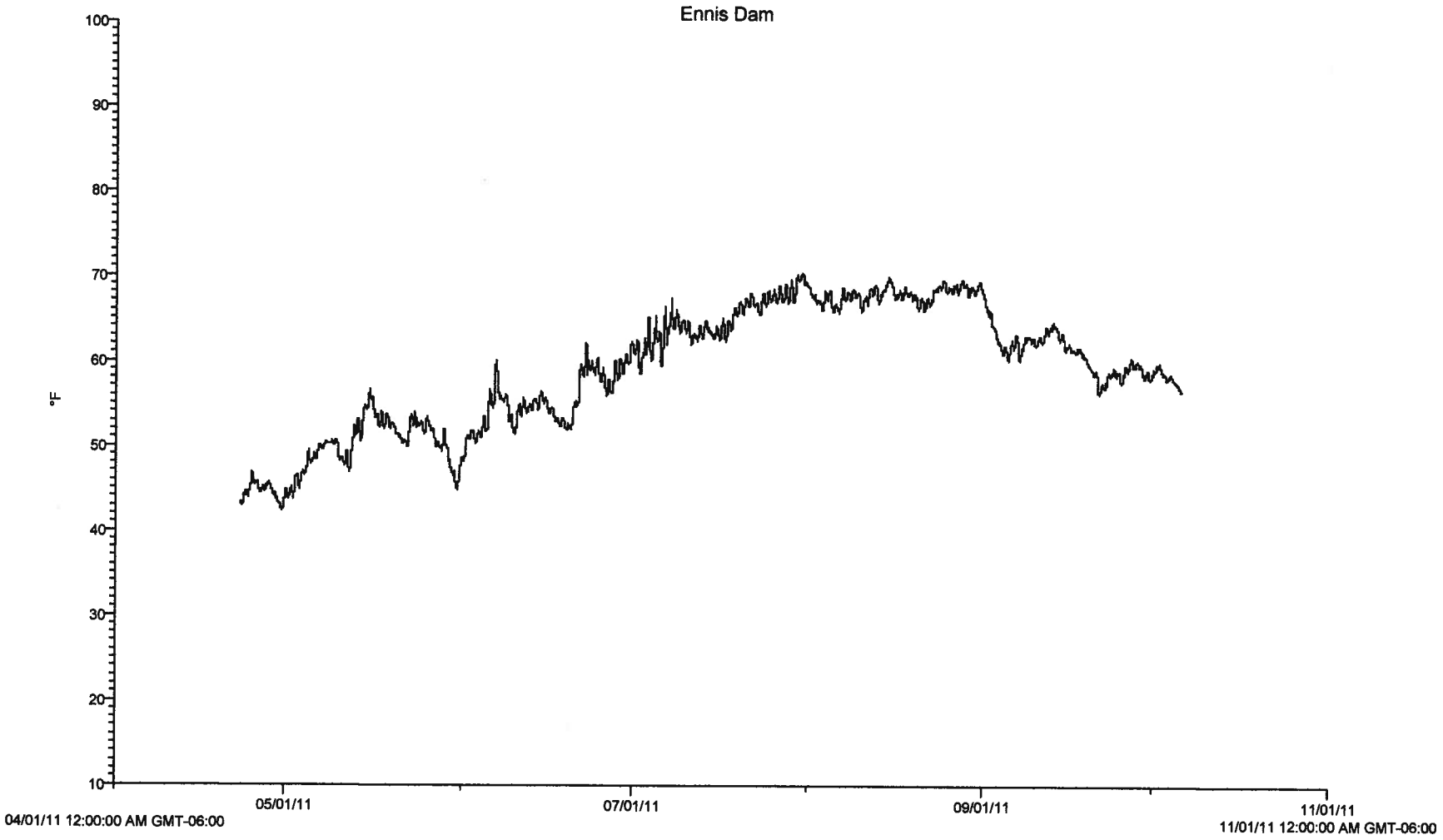
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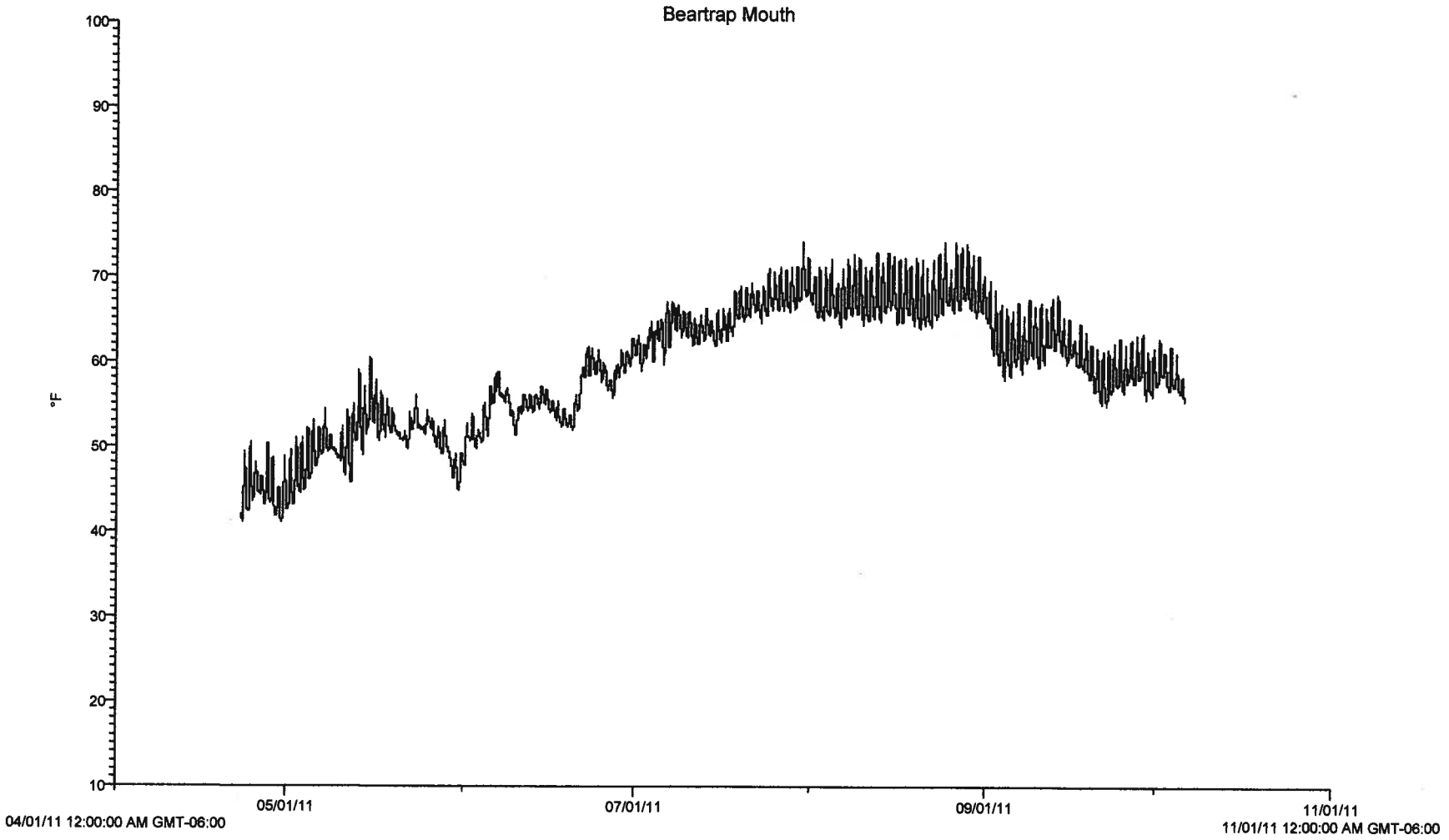
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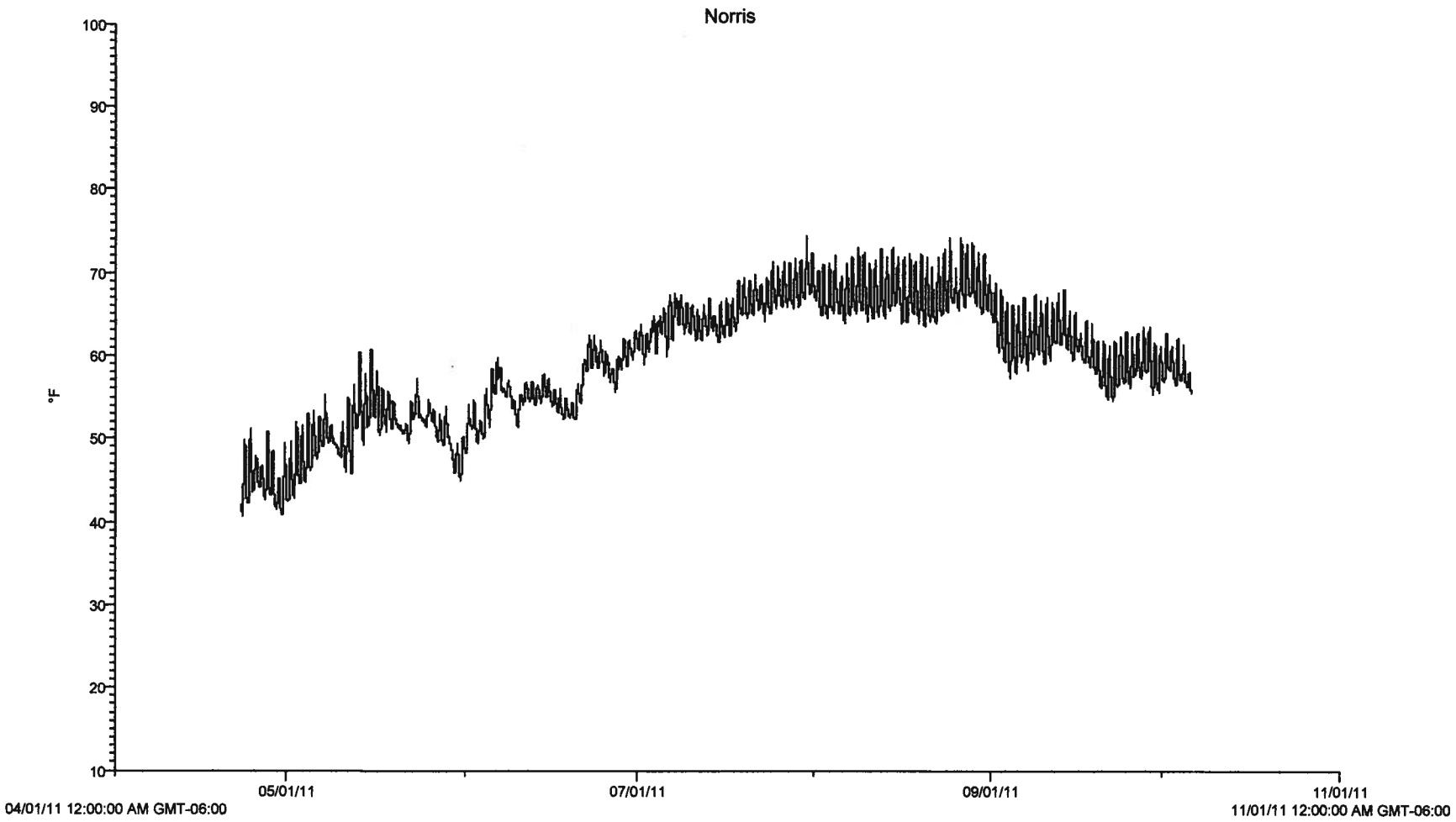
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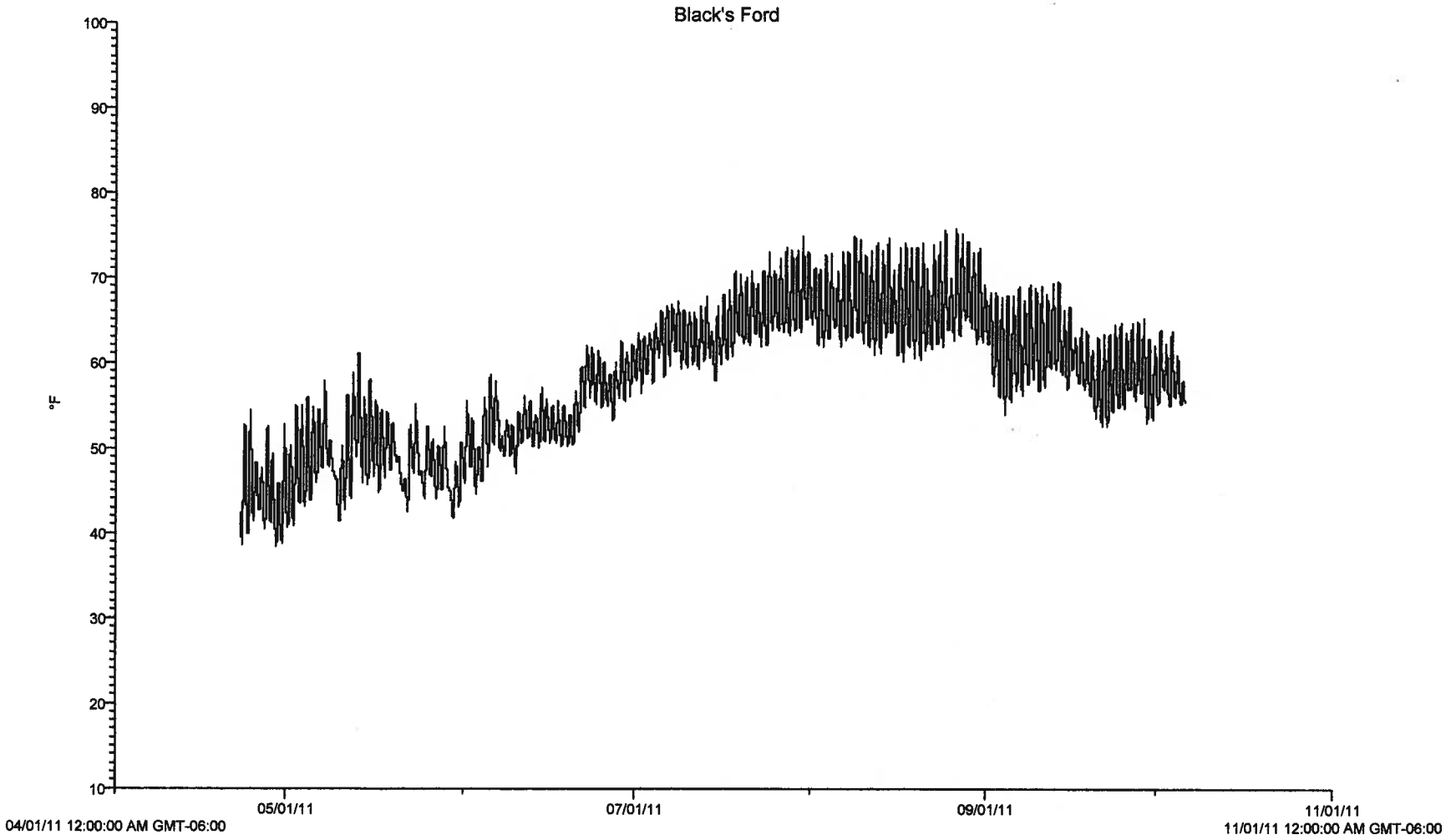
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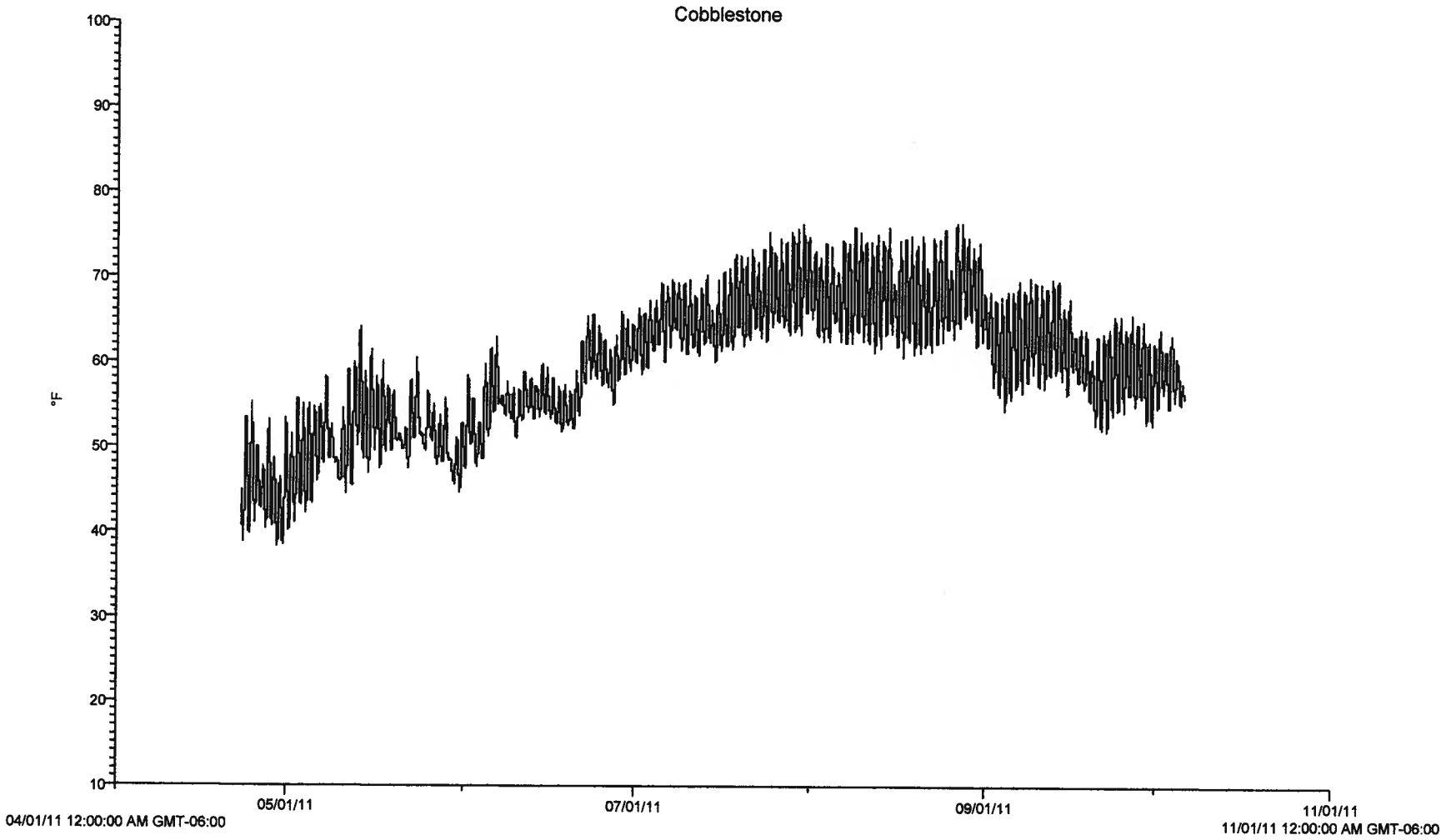
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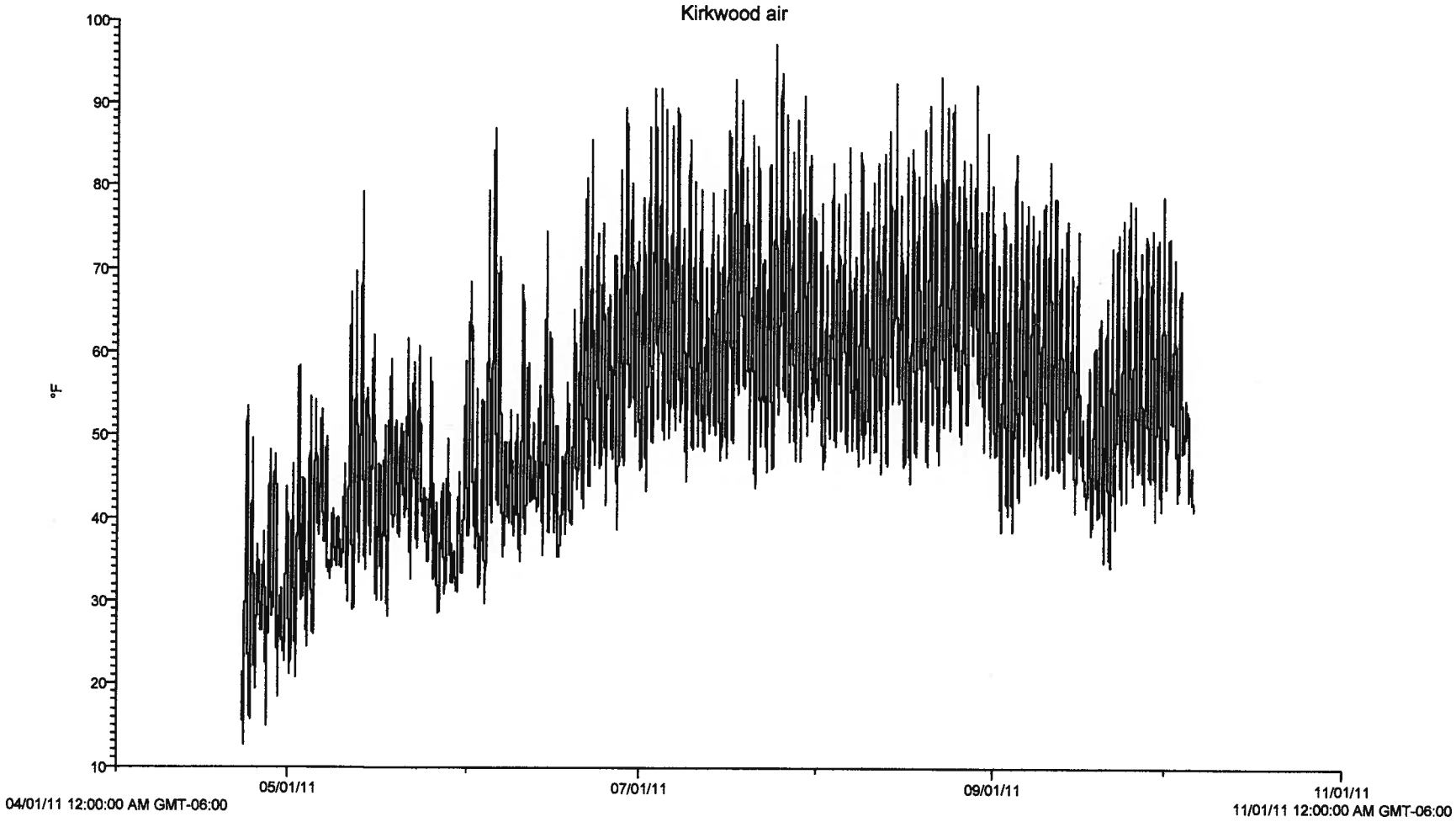
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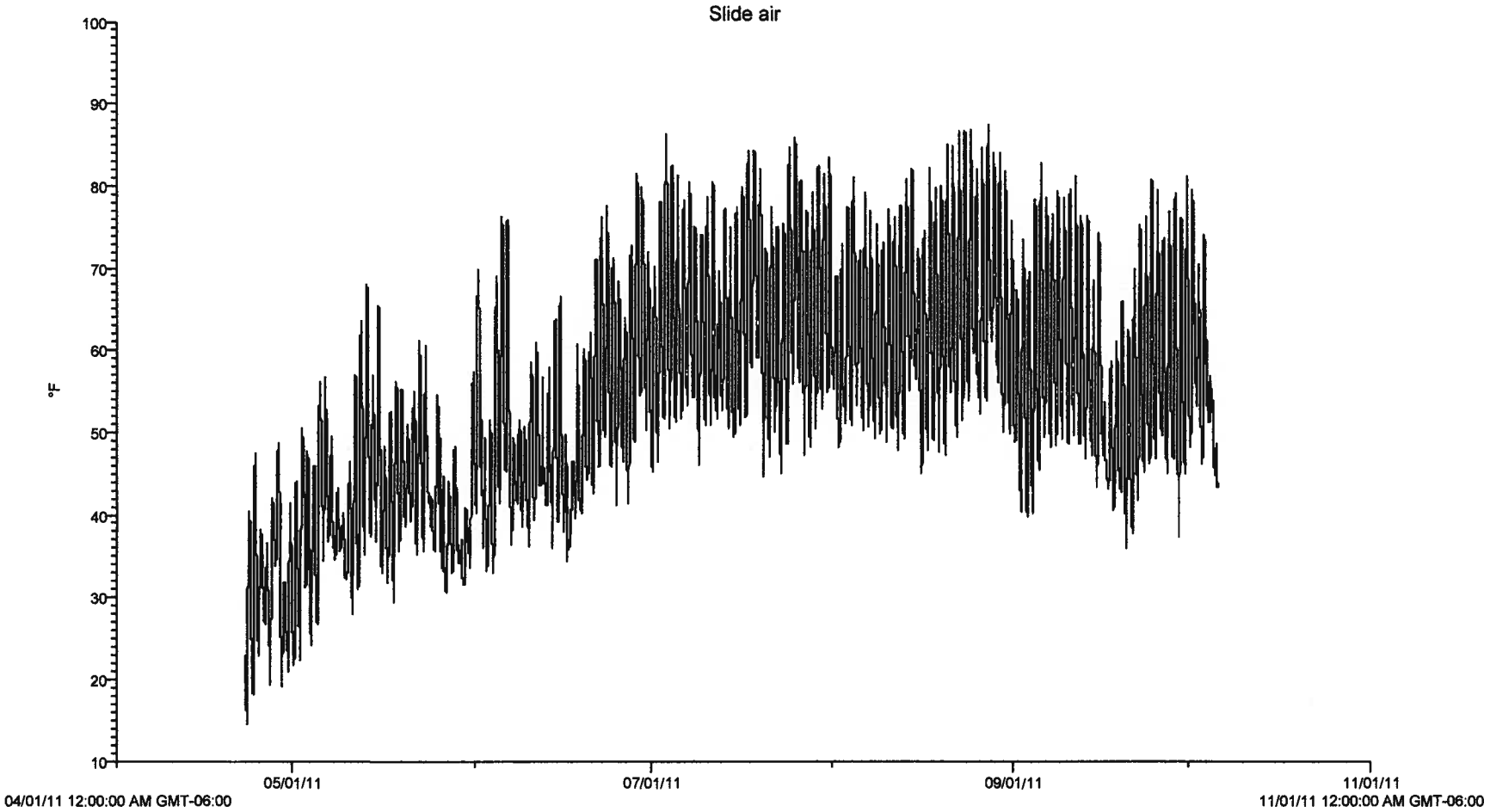
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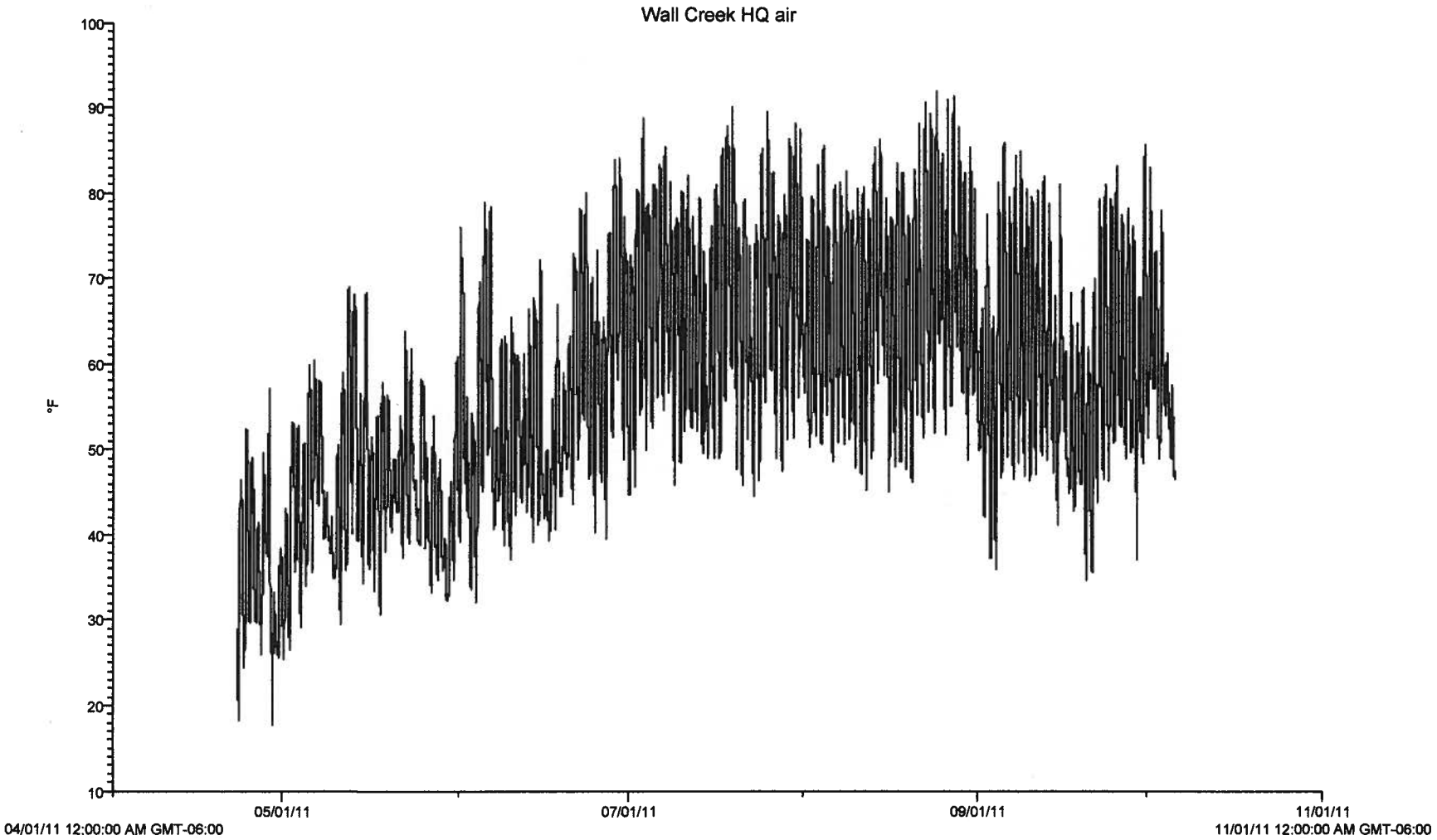
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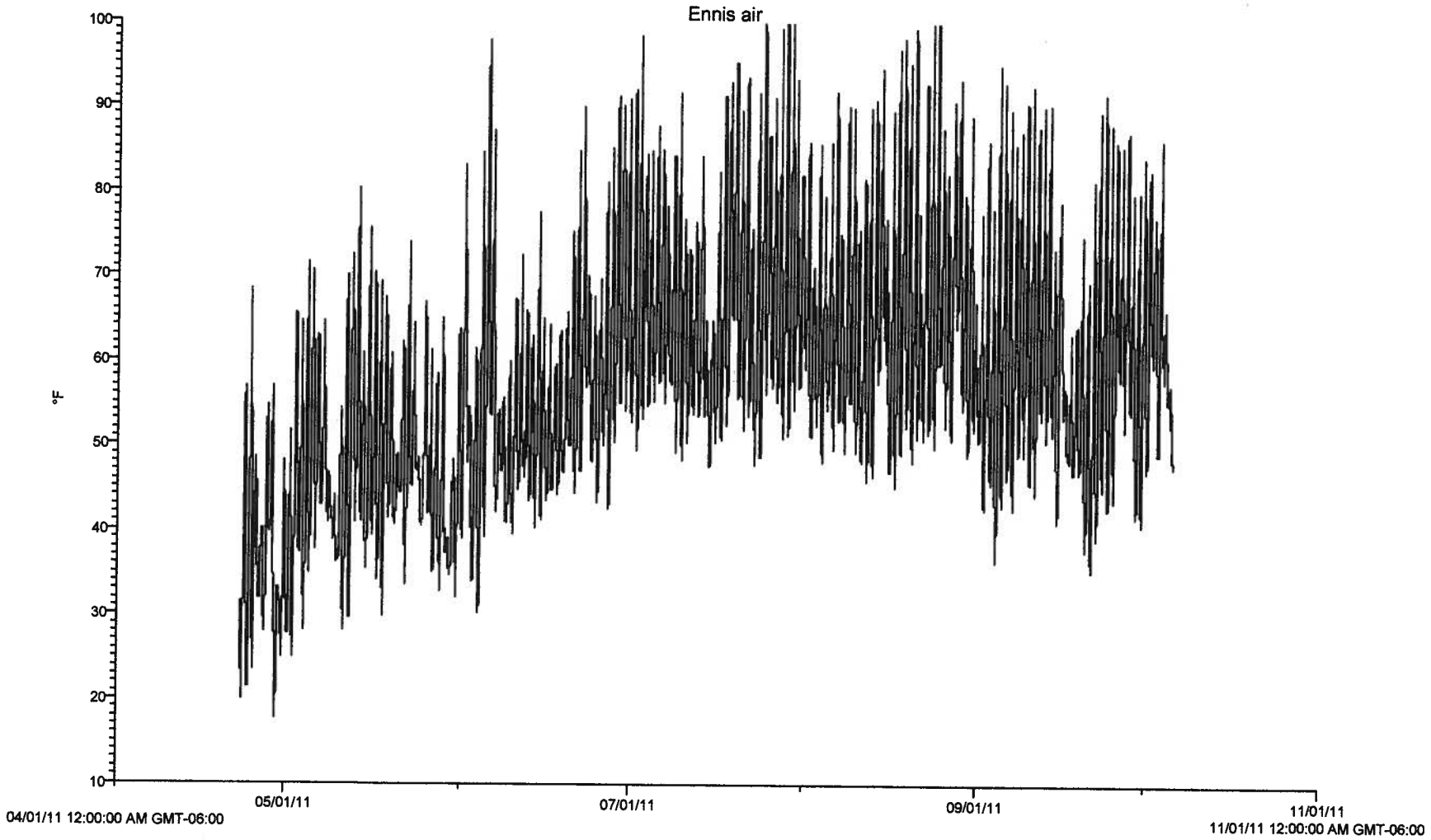
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04/01/11 12:00:00 AM GMT-06:00
05/01/11
07/01/11
09/01/11
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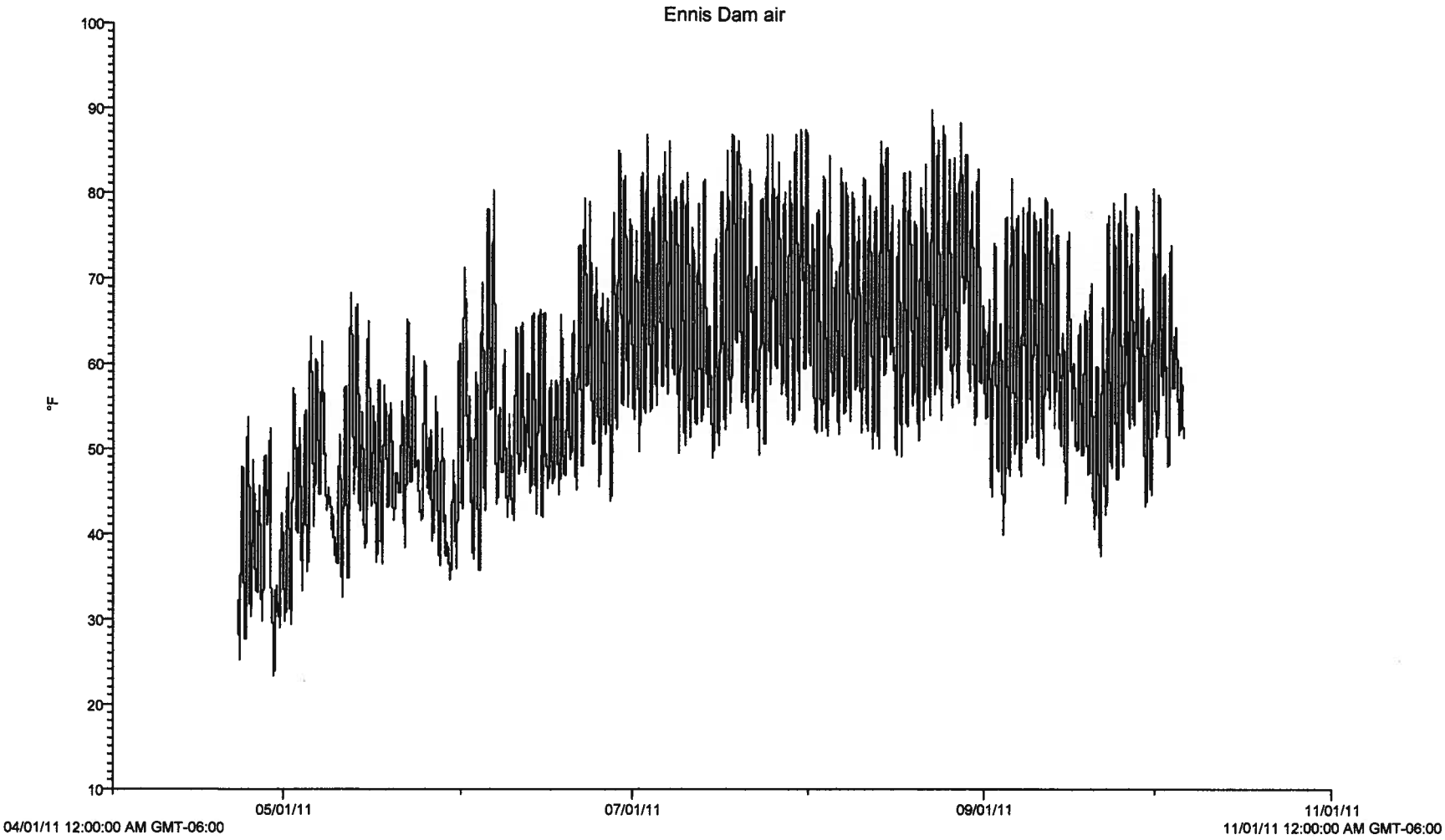
Ennis Dam air
°F
100
90
80
70
60
50
40
30
20
10
05/01/11
07/01/11
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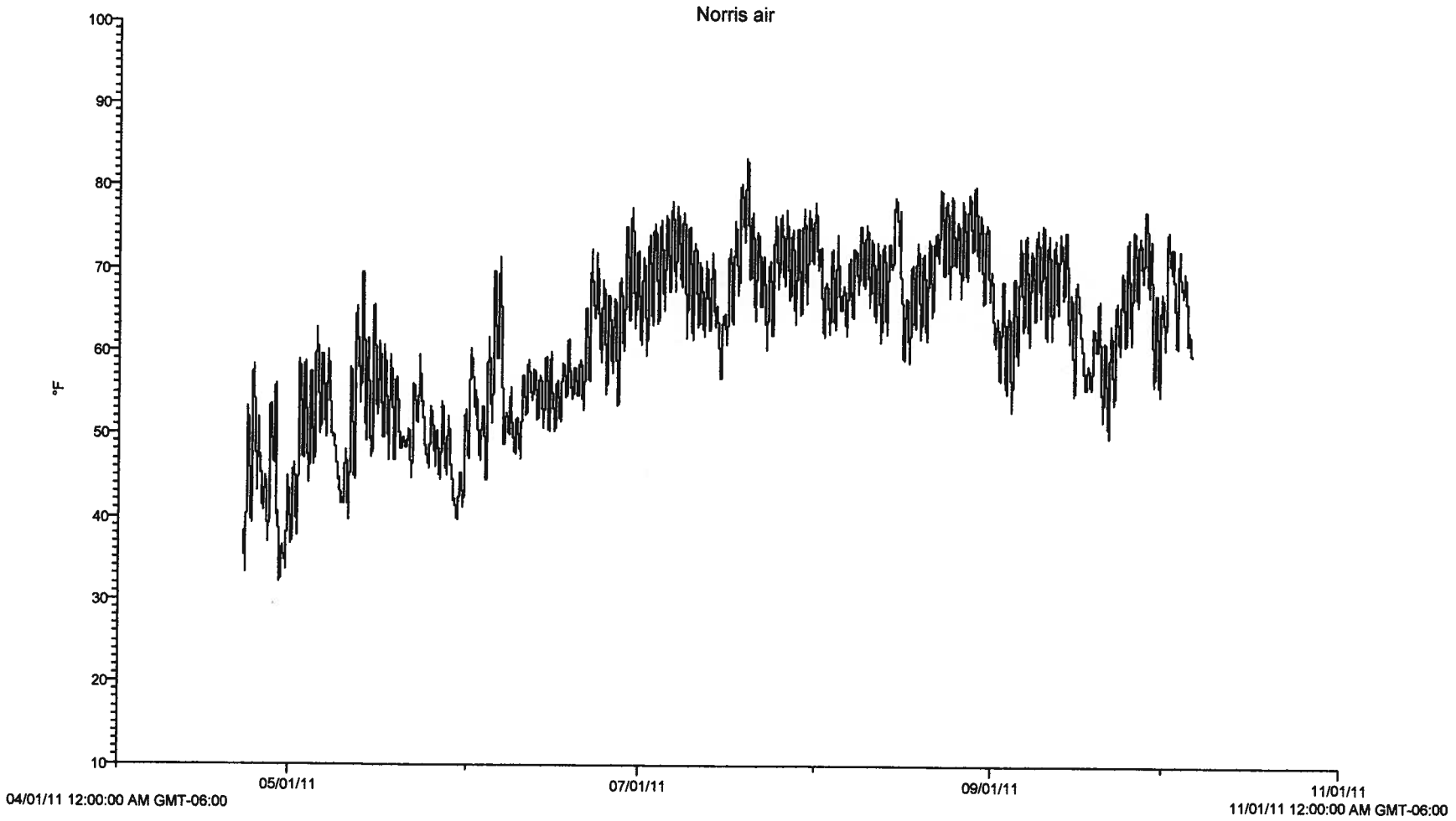
11/01/11
04/01/11 12:00:00 AM GMT-06:00
11/01/11 12:00:00 AM GMT-06:00


Norris air
100
90
80
70
60
50
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°F
05/01/11
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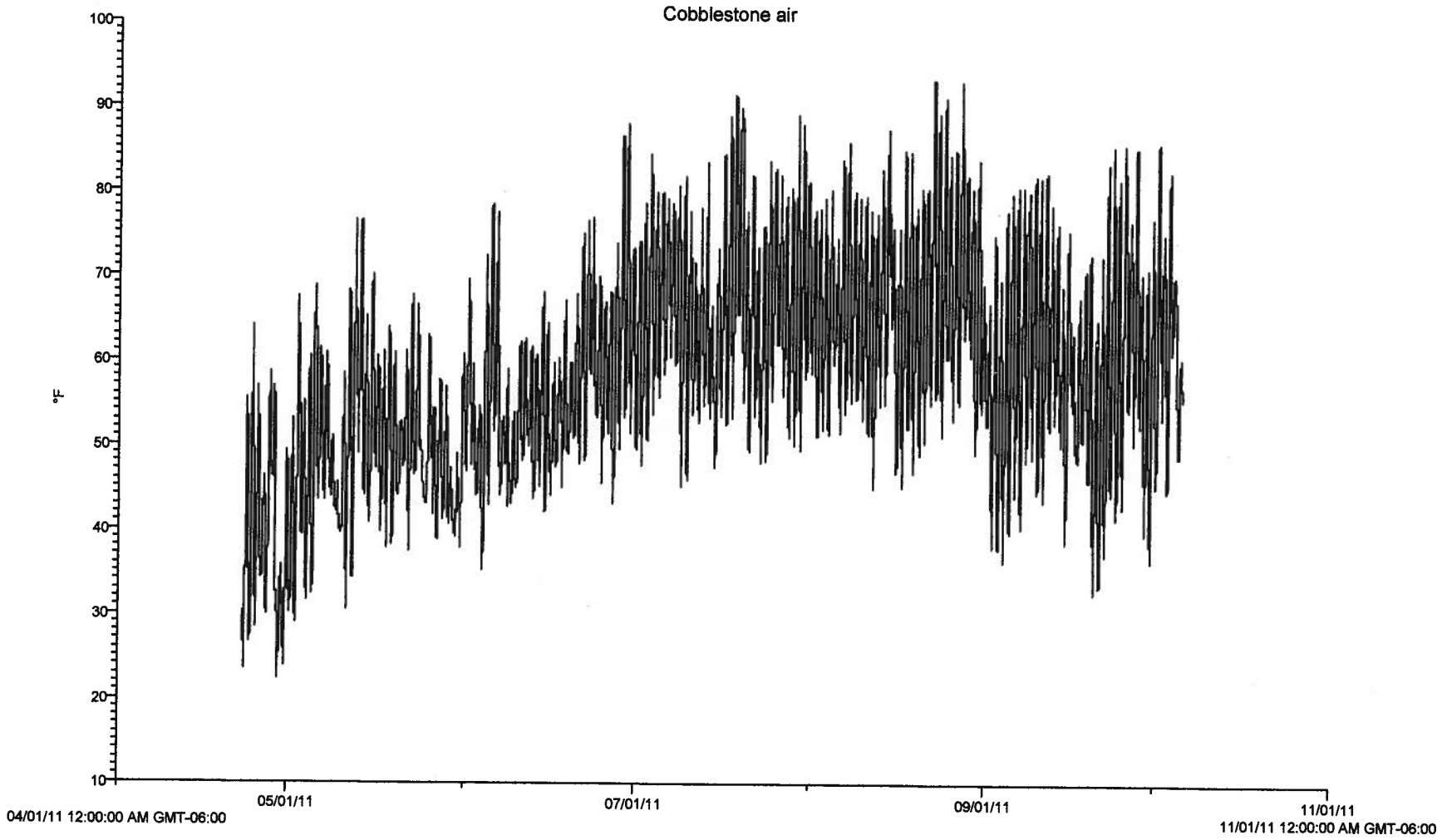
Cobblestone air
°F
100
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11/01/11
04/01/11 12:00:00 AM GMT-06:00
11/01/11 12:00:00 AM GMT-06:00

Appendix E2

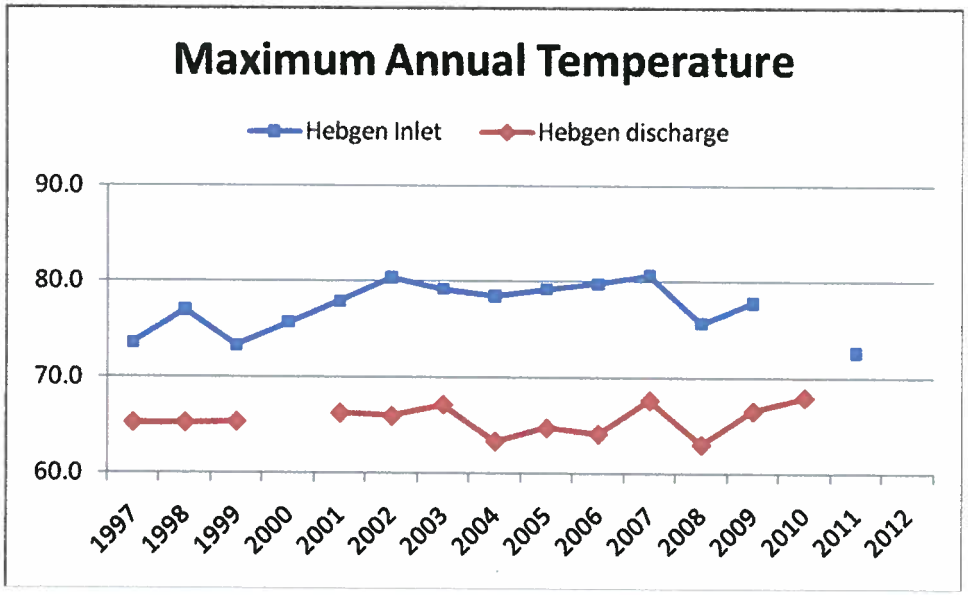
Comparison of maximum annual water temperatures at selected Madison River monitoring sites
1997 - 2011
See Figure 7 for locations

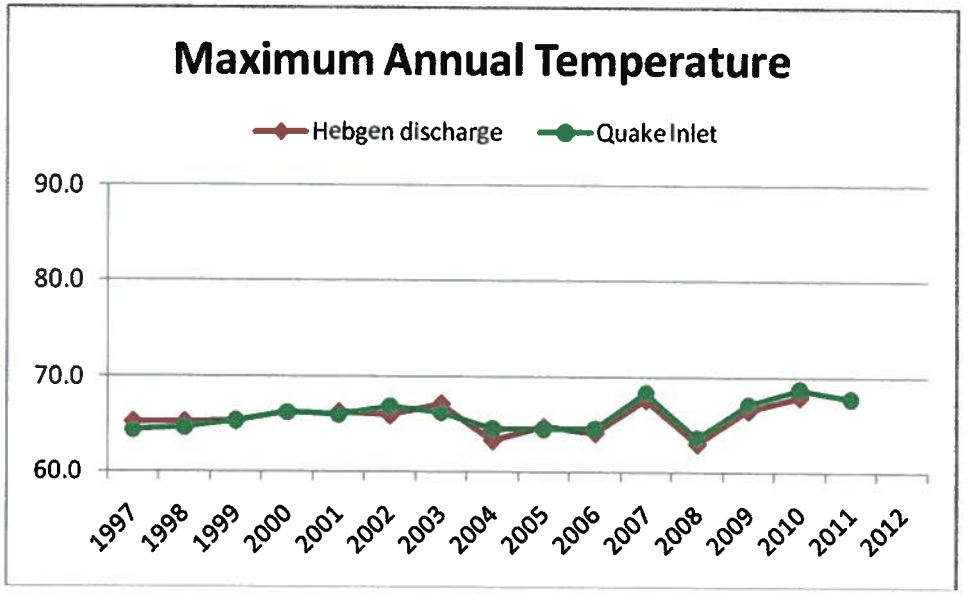
NOTES:

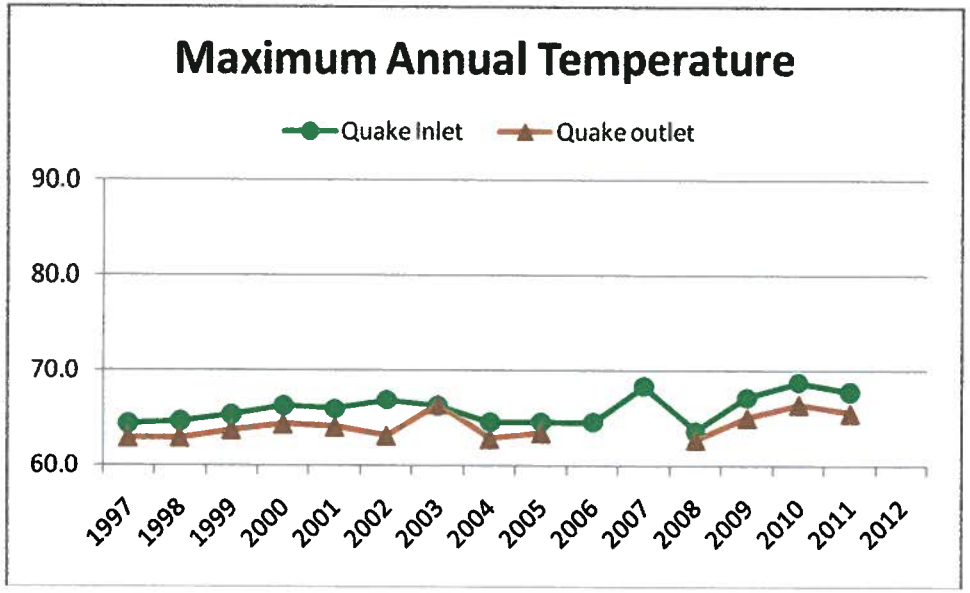
- Recorders at some locations were not recovered some years

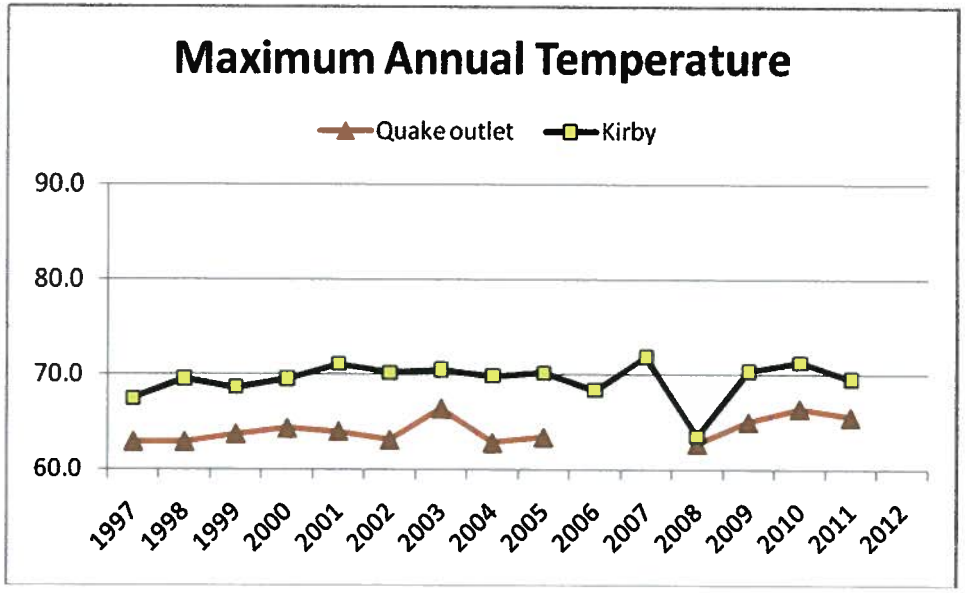
- It is important to note that the maximum temperatures at each site throughout the river did not all occur on the same day in any year, and that the maximum temperature at any given site may have been attained on more than just one day in a year

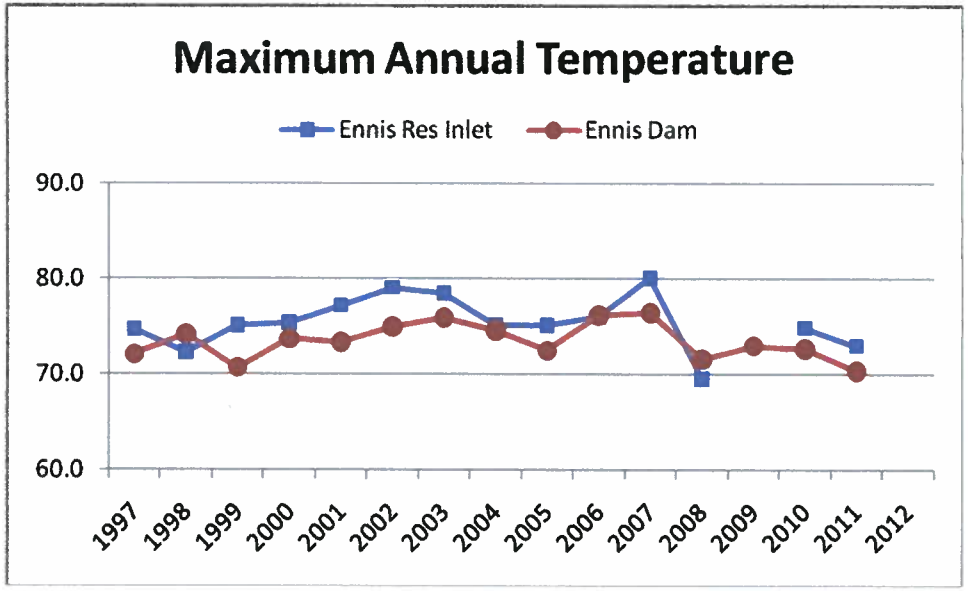
- Pulse flows were conducted out of Ennis Reservoir annually from 2000 – 2007. See report pages 9 and 36.

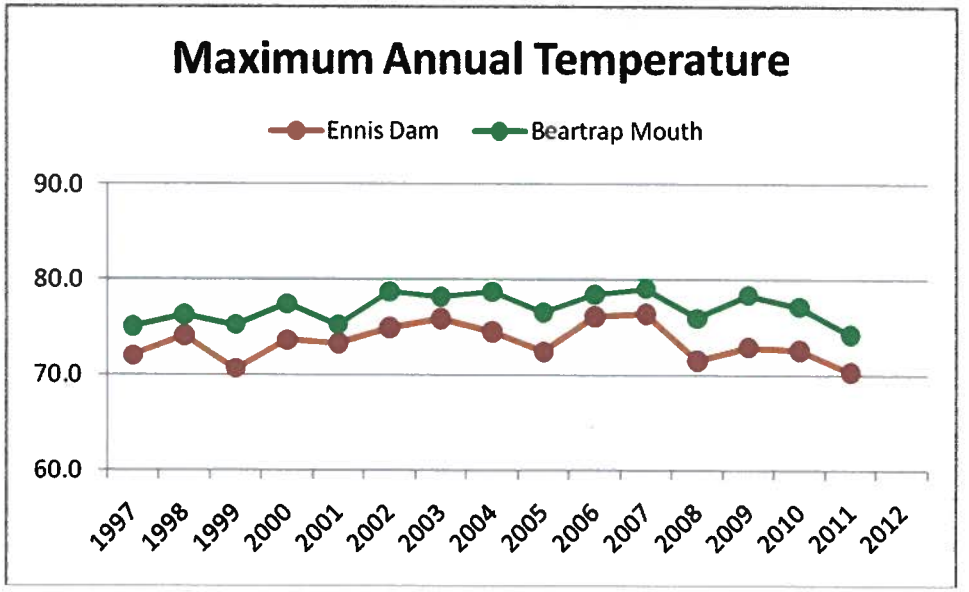

Maximum Annual Temperature
Hebgen Inlet
Hebgen discharge
90.0
80.0
70.0
60.0
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

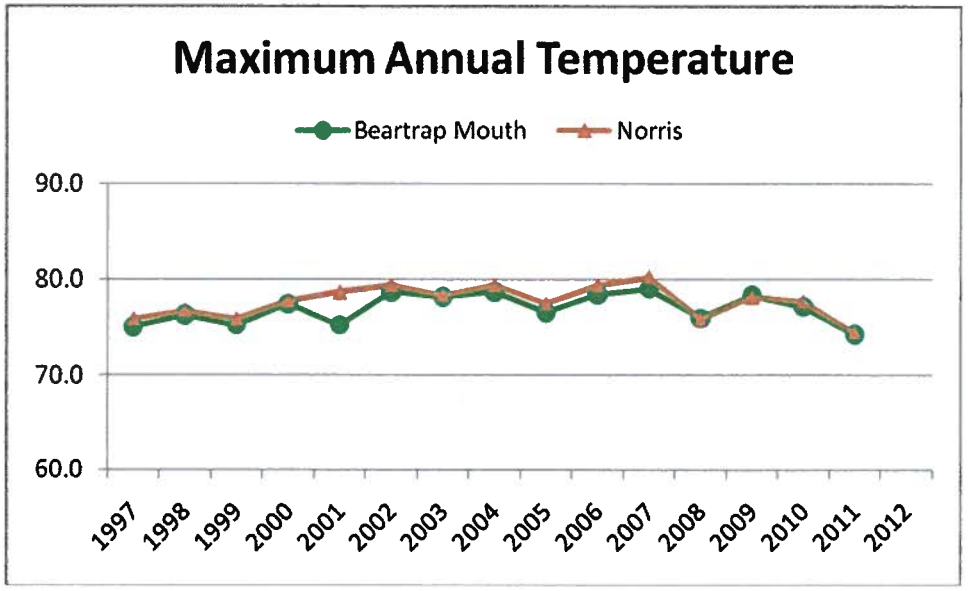

Maximum Annual Temperature
Hebgen discharge
Quake Inlet
90.0
80.0
70.0
60.0
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012


Maximum Annual Temperature
Quake Inlet
Quake outlet
90.0
80.0
70.0
60.0
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012


Maximum Annual Temperature
Quake outlet
Kirby
90.0
80.0
70.0
60.0
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012


Maximum Annual Temperature
Ennis Res Inlet
Ennis Dam
90.0
80.0
70.0
60.0
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012


Maximum Annual Temperature
Ennis Dam
Beartrap Mouth
90.0
80.0
70.0
60.0
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012


Maximum Annual Temperature
Beartrap Mouth
Norris
90.0
80.0
70.0
60.0
1997
1998
1999
2000
2001
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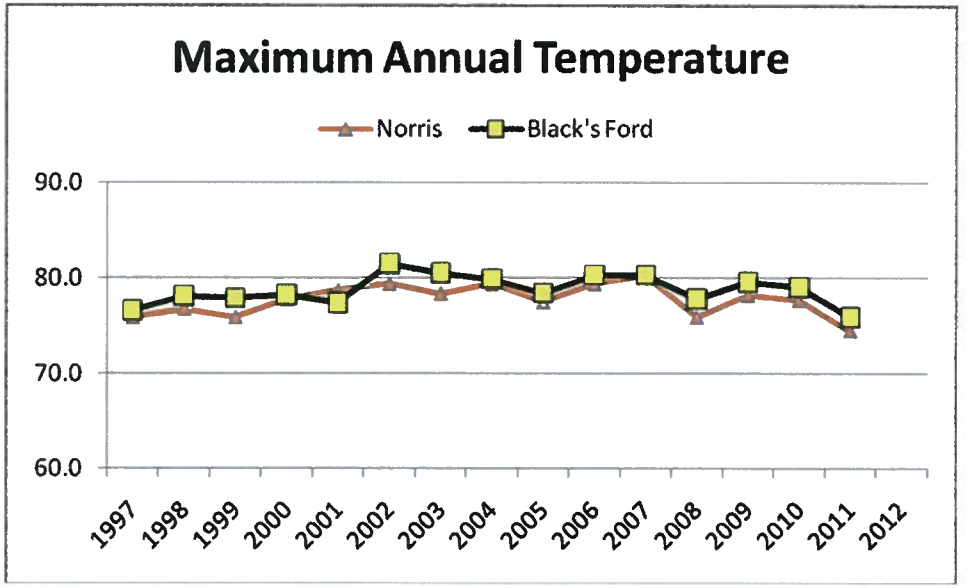
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012


Maximum Annual Temperature
Norris
Black's Ford
90.0
80.0
70.0
60.0
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

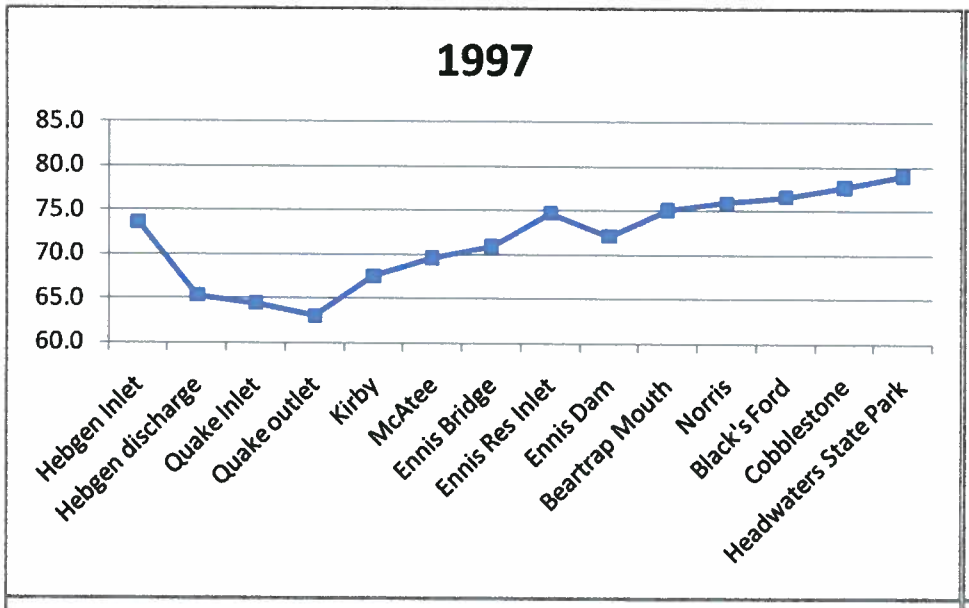
Appendix E3

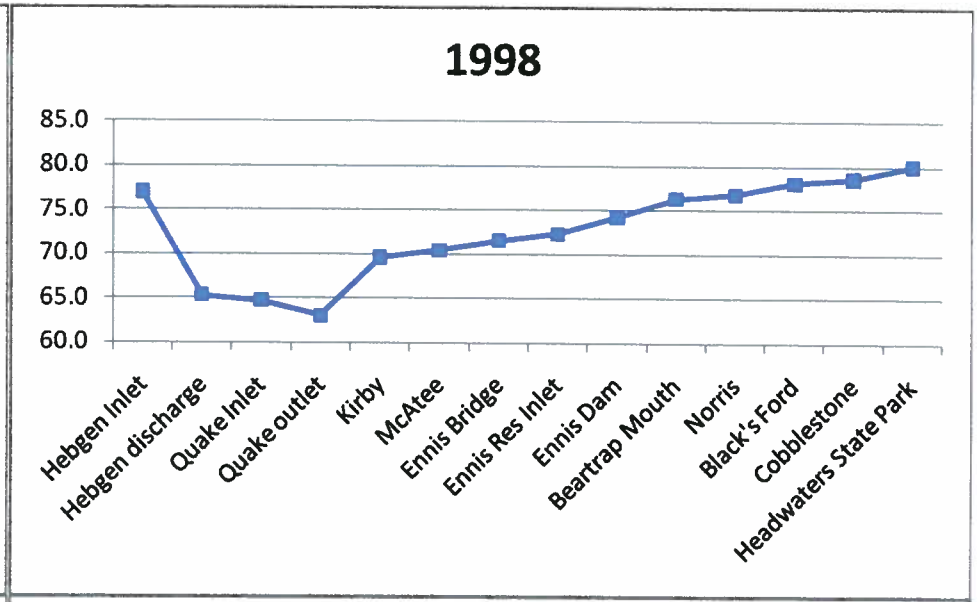
Maximum annual water temperatures recorded at Madison River monitoring sites
1997 - 2011
See Figure 7 for locations

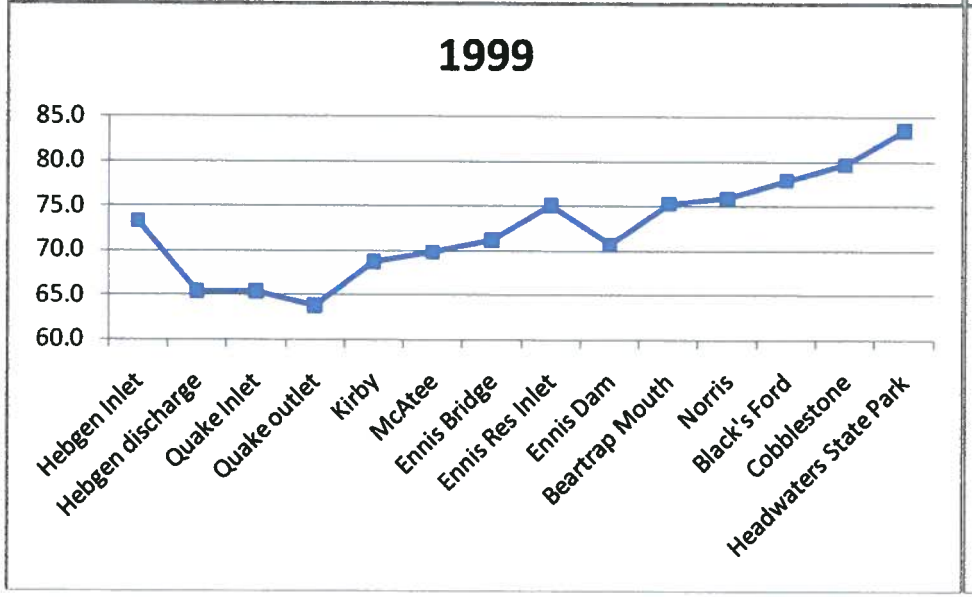
NOTES:

- Recorders at some locations were not recovered some years

- It is important to note that the maximum temperatures at each site throughout the river did not all occur on the same day in any year, and that the maximum temperature at any given site may have been attained on more than just one day in a year


1997
85.0
80.0
75.0
70.0
65.0
60.0
Hebgen Inlet
Hebgen discharge
Quake Inlet
Quake outlet
Kirby
McAtee
Ennis Bridge
Ennis Res Inlet
Ennis Dam
Beartrap Mouth
Norris
Black's Ford
Cobblestone
Headwaters State Park


1998
85.0
80.0
75.0
70.0
65.0
60.0
Hebgen Inlet
Hebgen discharge
Quake Inlet
Quake outlet
Kirby
McAtee
Ennis Bridge
Ennis Res Inlet
Ennis Dam
Beartrap Mouth
Norris
Black's Ford
Cobblestone
Headwaters State Park


1999
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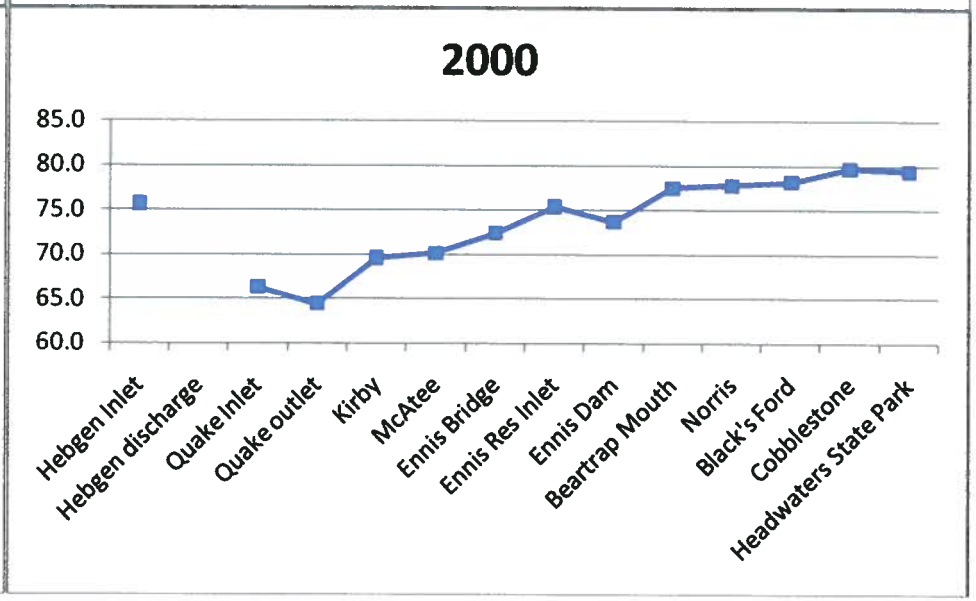
Hebgen Inlet
Hebgen discharge
Quake Inlet
Quake outlet
Kirby
McAtee
Ennis Bridge
Ennis Res Inlet
Ennis Dam
Beartrap Mouth
Norris
Black's Ford
Cobblestone
Headwaters State Park


2000
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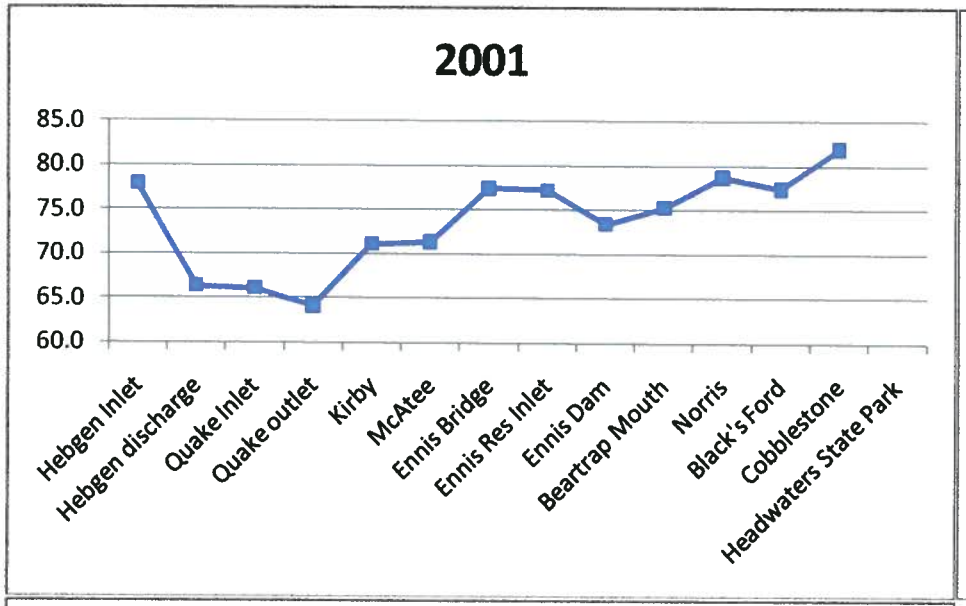
80.0
75.0
70.0
65.0
60.0
Hebgen Inlet
Hebgen discharge
Quake Inlet
Quake outlet
Kirby
McAtee
Ennis Bridge
Ennis Res Inlet
Ennis Dam
Beartrap Mouth
Norris
Black's Ford
Cobblestone
Headwaters State Park


2001
85.0
80.0
75.0
70.0
65.0
60.0
Hebgen Inlet
Hebgen discharge
Quake Inlet
Quake outlet
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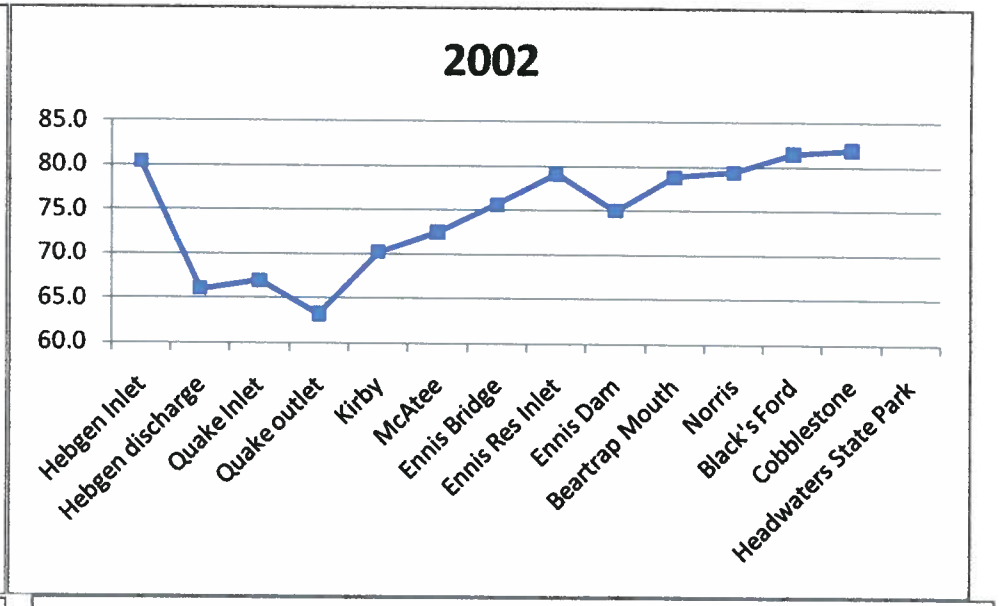
McAtee
Ennis Bridge
Ennis Res Inlet
Ennis Dam
Beartrap Mouth
Norris
Black's Ford
Cobblestone
Headwaters State Park


2002
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Hebgen Inlet
Hebgen discharge
Quake Inlet
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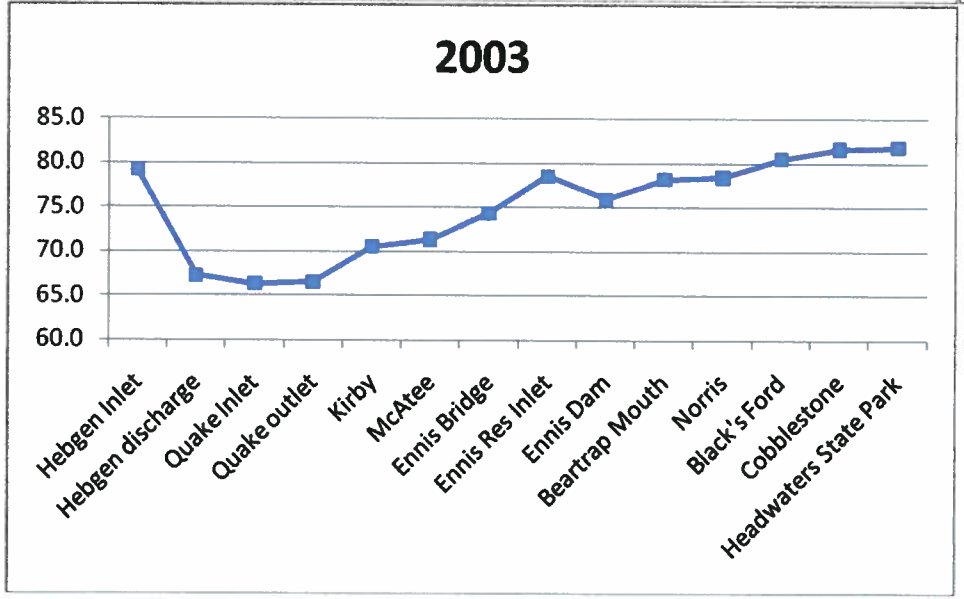
Headwaters State Park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Hebgen discharge
Quake Inlet
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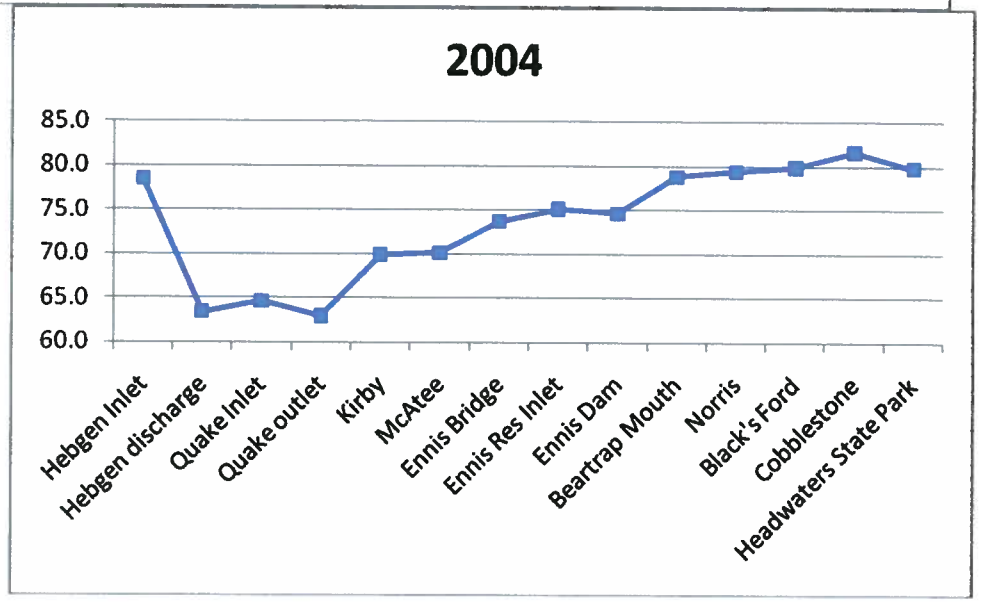
Norris
Black's Ford
Cobblestone
Headwaters State Park


2004
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60.0
Hebgen Inlet
Hebgen discharge
Quake Inlet
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Ennis Bridge
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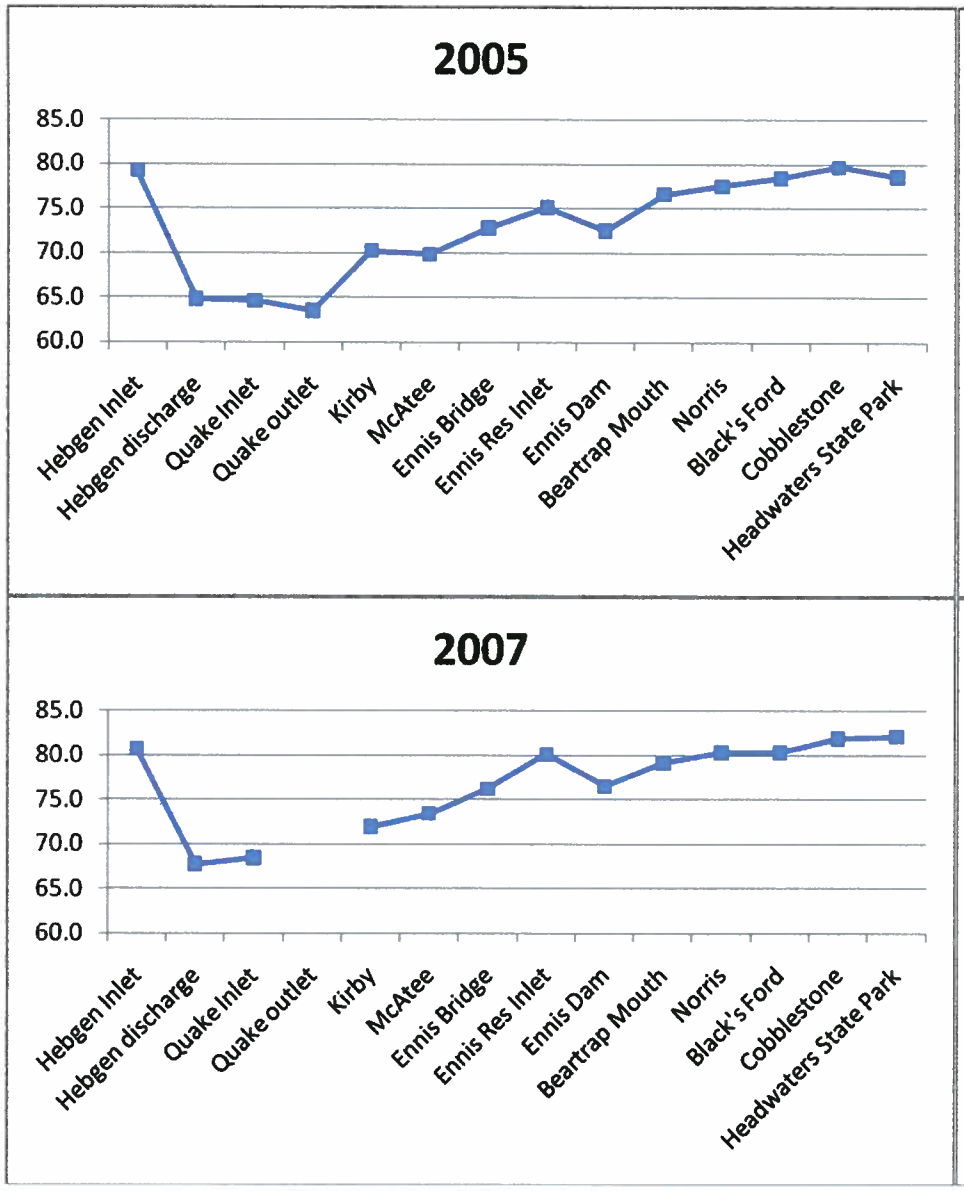
Ennis Dam
Beartrap Mouth
Norris
Black's Ford
Cobblestone
Headwaters State Park


2005
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Hebgen discharge
Quake Inlet
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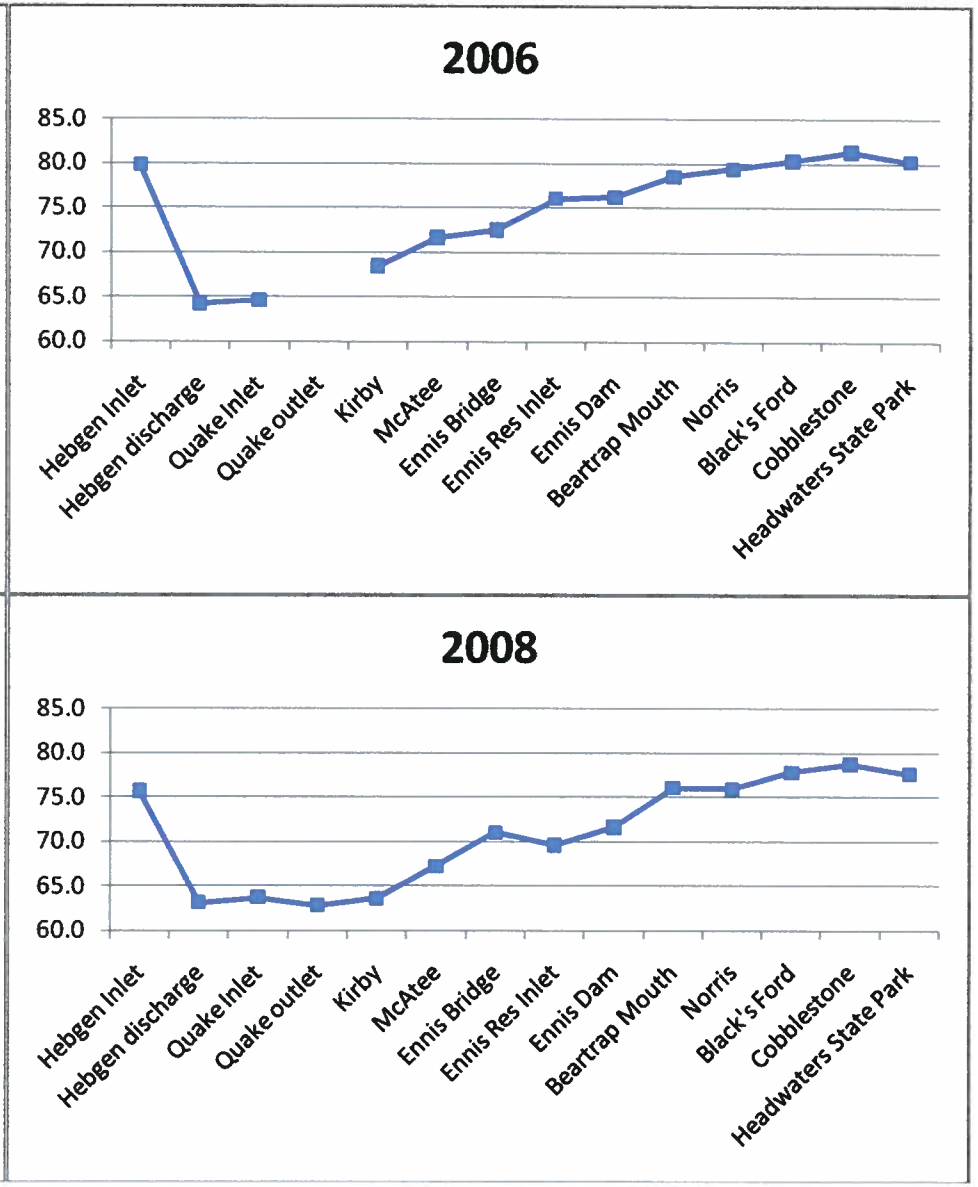
Ennis Bridge
Ennis Res Inlet
Ennis Dam
Beartrap Mouth
Norris
Black's Ford
Cobblestone
Headwaters State Park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Hebgen discharge
Quake Inlet
Quake outlet
Kirby
McAtee
Ennis Bridge
Ennis Res Inlet
Ennis Dam
Beartrap Mouth
Norris
Black's Ford
Cobblestone
Headwaters State Park


2007
85.0
80.0
75.0
70.0
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60.0
Hebgen Inlet
Hebgen discharge
Quake Inlet
Quake outlet
Kirby
McAtee
Ennis Bridge
Ennis Res Inlet
Ennis Dam
Beartrap Mouth
Norris
Black's Ford
Cobblestone
Headwaters State Park


2008
85.0
80.0
75.0
70.0
65.0
60.0
Hebgen Inlet
Hebgen discharge
Quake Inlet
Quake outlet
Kirby
McAtee
Ennis Bridge
Ennis Res Inlet
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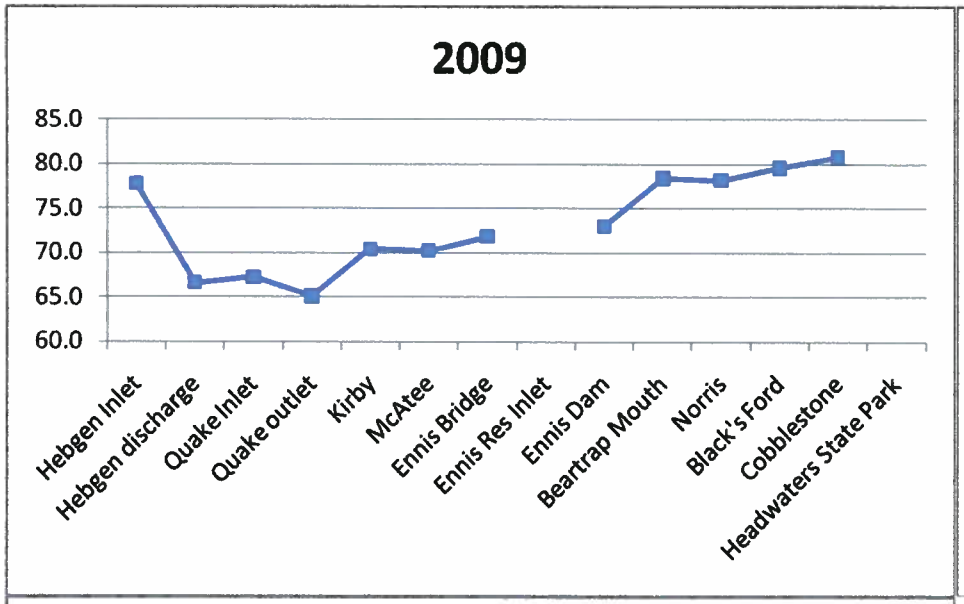
Beartrap Mouth
Norris
Black's Ford
Cobblestone
Headwaters State Park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Hebgen discharge
Quake Inlet
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Norris
Black's Ford
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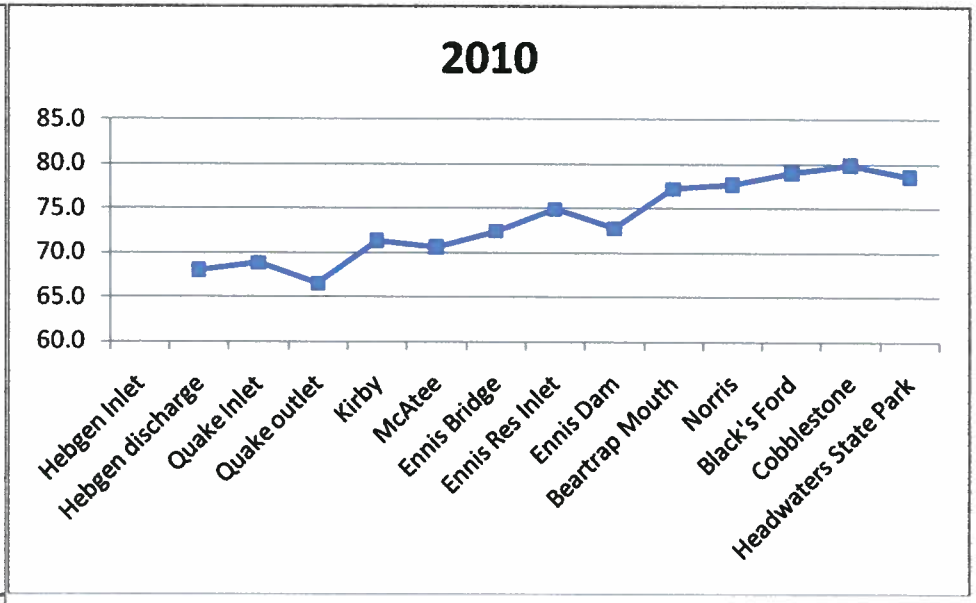
Headwaters State Park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Hebgen Inlet
Hebgen discharge
Quake Inlet
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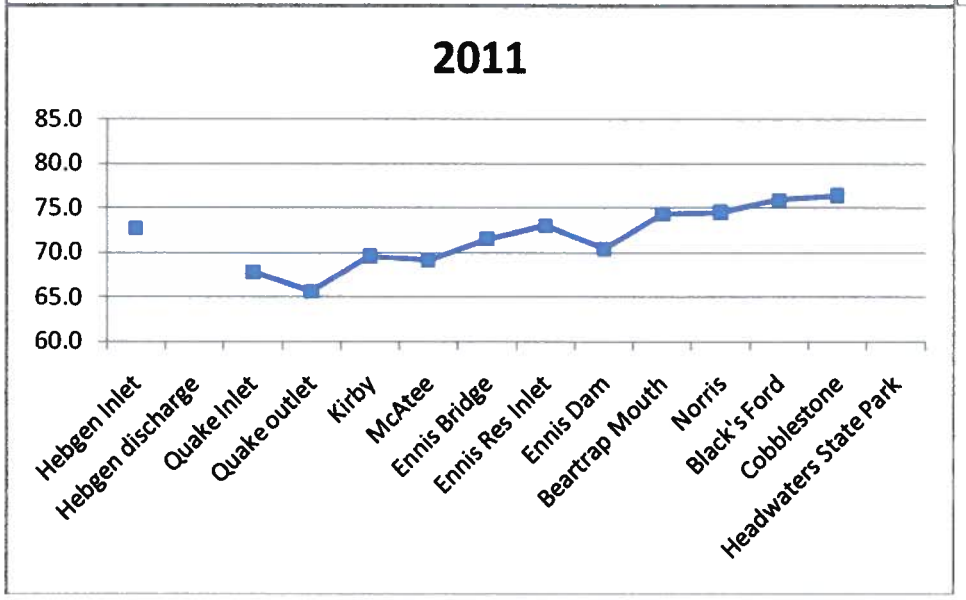
Headwaters State Park


2011
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65.0
60.0
Hebgen Inlet
Hebgen discharge
Quake Inlet
Quake outlet
Kirby
McAtee
Ennis Bridge
Ennis Res Inlet
Ennis Dam
Beartrap Mouth
Norris
Black's Ford
Cobblestone
Headwaters State Park

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

## Sun Ranch Hatchery Contributions and Production
## 2001 – 2011

| Year | Donor Stream | M:F spawned | # eggs produced | Recipient Water | # eggs/fry out |
|---|---|---|---|---|---|
| 2001 | Papoose Ck - Madison | NA | | Sun Pond | 356 fry total |
| | MF Cabin Ck - Madison | 23:12 | | Sun Pond | |
| 2002 | WF Wilson Ck - Gallatin | ?:6 | | Sun brood pond | 483 fry |
| | MF Cabin Ck - Madison | ?:3 | | Sun brood pond | 104 fry |
| 2003 | Ray Ck - Big Belts | 25:9 | 2,420 | Sun brood pond | 566 fry |
| | | | | Bar None Pond | 560 fry |
| | Prickly Pear Ck - Missouri | 4:1 | NA | Prickly Pear | 28 |
| | | | | Eureka Ck | 120 |
| | | | | Little Tizer | 52 |
| | Hall Ck - Elkhorns | 4:1 | NA | Hall | 20 |
| | | | | Little Tizer | 91 |
| 2004 | Cottonwood Ck - Blacktail | 12:6 | 1,652 | Sun brood pond | 820 fry |
| | Muskrat Ck - Elkhorns | 15:7 | 2,028 | | |
| | Ray F x McClure M (Madison) | 4:8 | 1,410 | Bar None Pond | 814 fry |
| | Ray F x Hall M | 2:1 | 362 | | |
| 2005 | Cottonwood Ck - Blacktail | 13:6 | 2,849 | Sun brood pond | 528 fry |
| | | | | disease testing | 11 fry |
| | Browns Ck - Beaverhead | 10:5 | 772 | Sun brood pond | 646 fry |
| | Sun brood pond | 37:16 | 13,851 | Sun brood pond | 800 fry |
| | | | | Sun Pond disease sentinels | 120 fry |
| | | | | disease testing | 100 fry |
| | | | | euthanized to reduce hatchery load | 750 fry |
| | | | | Moret Pond | 700 fry |
| | | | | calibration of CWT injector | 5 fry |
| | Muskrat Ck - Elkhorns | 18:9 | NA | SF Crow Ck | 2262 eyed eggs |
| 2006 | Browns Ck | 1:1 | 301 | Sun brood pond | 284 fry |
| | Muskrat Ck - Elkhorns | 16:8 | 2,027 | Sun brood pond | 184 fry |
| | | | | Cherry Ck | 1750 eyed eggs |
| | Whites Gulch - Big Belt Mtns | 3:3 | 982 | Cherry Ck | 726 eyed eggs |

| Year | Donor Stream | M:F spawned | | Recipient Water | # eggs/fry out |
|---|---|---|---|---|---|
| 2007 | Muskrat Ck - Elkhorns | 11:22 | 6,533 | Cherry Ck | 5445 eyed eggs |
| | | | | Sun brood pond | 291 fry |
| | Ray Ck - Big Belt Mtns | 13:25 | 4,371 | Cherry Ck | 3467 eyed eggs |
| | | | | Sun brood pond | 194 fry |
| | Whites Gulch - Big Belt Mtns | 4:8 | 1,688 | Cherry Ck | 1015 eyed eggs |
| | | | | Sun brood pond | 59 fry |
| | Sun brood pond | 37:17 | NA | Cherry Ck | 2994 eyed eggs |
| | | | | Sun brood pond | 326 fry |
| | | | | High Lake (YNP) | 1611 eyed eggs |
| | Last Chance Ck - Madison (YNP) | 12:8 | NA | High Lake YNP | 177 eyed eggs |
| 2008 | Muskrat Ck - Elkhorns | 28:14 | NA | Cherry Ck | 3199 eyed eggs |
| | Ray Ck - Big Belt Mtns | 23:12 | NA | Cherry Ck | 1700 eyed eggs |
| | Whites Gulch - Big Belt Mtns | 11:6 | NA | Cherry Ck | 1015 eyed eggs |
| | | | | Sun brood pond | 117 fry |
| | Sun brood pond | 28:10 | NA | Cherry Ck | 3218 eyed eggs |
| | | | | Sun brood pond | 571 fry |
| | | | | High Lake (YNP) | 2844 eyed eggs |
| | Last Chance Ck - Madison (YNP) | 13:8 | NA | High Lake (YNP) | 286 eyed eggs |
| | | | | Sun brood pond | 70 fry |
| 2009 | Muskrat Ck - Elkhorns | 24:12 | NA | Cherry Ck | 4134 eyed eggs |
| | | | | Sun brood pond | 311 fry |
| | Whites Gulch - Big Belt Mtns | 8:5 | NA | Cherry Ck | 630 eyed eggs |
| | | | | Cherry Lake | 500 fry |
| | | | | Sun Pond | 283 fry |
| | | | | Cottonwood Ck (R4) | 1350 eyed eggs |
| | Ray Ck - Big Belt Mtns | 20:10 | NA | Cherry Ck | 1911 eyed eggs |
| | | | | Sun brood pond | 15 fry |
| | Geode Ck (YNP) | 17:16 | NA | High Lake YNP | 838 eyed eggs |
| | WF Wilson Ck - Gallatin | NA | NA | eggs destroyed - hybridized | |

| Year | Donor Stream | M:F spawned | | Recipient Water | # eggs/fry out |
|---|---|---|---|---|---|
| 2010 | Last Chance - Yellowstone NP | 5:5 | NA | Little Tepee - Hebgen basin | 443 eyed eggs |
| | Wally McClure - Hebgen trib | 10:0 | NA | Little Tepee - Hebgen basin | |
| | Brays Canyon | 7:7 | NA | Cherry Creek | 1066 eyed eggs |
| | | | | Sun brood pond | 123 fry |
| | Prickly Pear - Elkhorm Mtns | 8:4 | NA | Eureka Creek - Elkhorn Mtns | 641 eyed eggs |
| | Wild Horse | 5:3 | NA | Elkhorn - Gallatin | 678 eyed eggs |
| | | | | Wild Horse | 76 eyed eggs |
| | Geode Creek - YNP | 24:18 | NA | EF Specimen Creek | 4156 eyed eggs |
| | Sun brood pond | 10:5 | NA | Cherry Creek | 398 eyed eggs |
| | | | | | 3400 fry |
| | | | | Sun brood pond | 496 fry |
| | WF Wilson | 1:1 | NA | eggs discarded - male was hybrid | |
| 2011 | Sun brood pond | 16:7 | 6,488 | Sun brood pond | 818 fry |
| | | | | Cherry Creek | 848 fry |
| | Whites Gulch - Big Belt Mtns | 7:7 | 1,296 | Cherry Lake | 458 fry |
| | | | | Cottonwood Ck FWP R4 | 498 eyed eggs |
| | Muskrat Ck - Elkhorns | 12:6 | 1,204 | Sun brood pond | 87 fry |
| | | | | EF Specimen Creek | 1046 eyed eggs |
| | Geode Creek (YNP) | 16:8 | 1,628 | EF Specimen Creek | 1200 eyed eggs |

# Appendix H

## PPL Montana funded Westslope Cutthroat Trout genetic testing results

# Westslope cutthroat populations tested for genetic status under PPL Montana 2188 Program

W = westslope cutthroat trout; Y = Yellowstone cutthroat trout; R = rainbow trout

| Stream | Collection date | Number of fish | lab analysis |
|---|---|---|---|
| SF Madison | 9/21-23/2011 | 242 | 216 @ 97.1%W x 2.9% R<br>26 various levels of intermediate |
| SF Madison | 8/3/2011 | 55 | 51 @ 97.1%W x 2.9% R<br>1 @ 0.8%W x 99.2%R<br>3 various levels of intermediate |
| Soap Ck | ? | 51 | 98% W x 2% R |
| McClure | 6/26/2010 | 19 | 100% W |
| Wild Horse | 6/26/2010 | 8 | 100% W |
| Last Chance | 6/25/2010 | 16 | 100% W |
| WF Wilson | 6/25/2010 | 2 | 1 @ 100%W; 1 WxR |
| Brays Canyon | 6/21/2010 | 26 | 100% W |
| Prickly Pear | 6/1/2010 | 19 | 18@100% W, 1@>99%W 1R? allele |
| Cherry Lake | numerous dates 2009 | 50 | 100% W |
| McClure | 10/7/2009 | 49 | 100% W |
| Brays Canyon | 10/1/2009 | 50 | 100% W |
| Prickly Pear | 10/1/2009 | 50 | 100% W |
| Little Tepee of Tepee of Grayling | 10/1/2009 | 10 | 92.3%W x 1.9%Y x 5.8%R |
| Hyde | 8/5/2009 | 25 | 88.5%W x 7.3%Y x 4.2%R |
| English George | 8/4/2009 | 25 | 93.4%W x 4.3%Y x 2.3%R |
| SF Madison | 7/16/2009 | 25 | 15 @ 97.7%W x 2.3%R<br>5 @ 0.8%Wx99.2%R<br>5 various levels of intermediate |
| Upper Fox | 9/18/2008 | 18 | 97% W x 3% R |
| Tepee Ck of Grayling Ck | 8/25/2008 | 8 | 51.5%W x 26.6%Y x 21.9%R |
| Wild Horse | 7/17/2008 | 30 | 100% W |
| Last Chance | 7/2/2008 | 21 | 100% W |

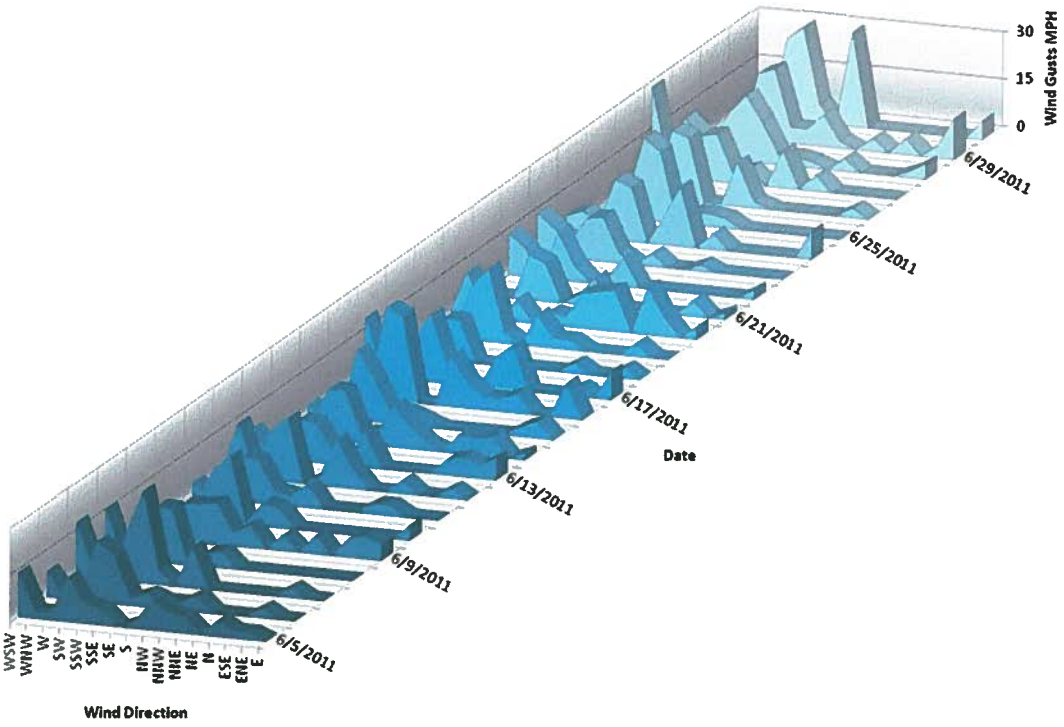
| | | | |
|---|---|---|---|
| Ray | 6/19/2008 | 60 | 100% w |
| Muskrat | 6/18/2008 | 52 | 100% W |
| Whites Gulch | 6/11/2008 | 54 | 100% W |
| Halfway | 9/26/2007 | 50 | 99.9% W x 0.1% R |
| Hall | 9/20/2007 | 50 | 100% W |
| Ray | 6/21/2007 | 45 | 100% W |
| Muskrat | 6/20/2007 | 38 | 100% W |
| Last Chance | 6/18/2007 | 20 | 100% W |
| Whites Gulch | 6/12/2007 | 24 | 100% W |
| Bear Ck | 9/19/2006 | 25 | 100% W |
| Bean Ck | 9/18/2006 | 25 | 100% W |
| Browns | 6/22/2006 | 25 | 100% W |
| Muskrat | 6/21/2006 | 24 | 100% W |
| Ray | 6/20/2006 | 35 | 100% W |
| Whites Gulch | 6/12/2006 | 31 | 100% W |
| Last Chance | 6/5/2006 | 30 | 100% W |
| Cabin Ck - mainstem | 10/17/2005 | 15 | 97% Wx 3% R swarm |
| Cabin Ck - Middle Fork | 10/11/2005 | 8 | mixture of pure W & hybrid WxR |
| Cabin Ck - Middle Fork | 10/11/2005 | 17 | mixture of pure W & hybrid WxR |
| Whites Gulch | 9/8/2005 | 50 | 100% W |
| Hellroaring Ck | 7/26/2005 | 10 | 27%Wx17%Yx56%R swarm |
| Little Elk River | 7/19/2005 | 10 | 100% Y |
| Arasta | 7/14/2005 | 25 | 87%Wx8%Rx5%Y |
| Browns | 6/28/2005 | 15 | 100% W |
| Soap Ck | 6/8/2005 | 10 | 94% Wx3% R swarm |
| Cottonwood Ck - Blacktail | 6/1/2005 | 19 | swarm - 1 fish had 3 Rb alleles; 18 fish no R alleles detected |
| Stone | 2005 | 30 | 100% W |
| Stone | 2004 | 50 | 100% W |
| Hall | 7/9/2004 | 2 | 100% W |
| McClure | 7/1/2004 | 8 | 100% W |
| Ray | 7/1/2004 | 5 | 100% W |
| Muskrat | 6/30/2004 | 22 | 100% W |

| | | | | |
|---|---|---|---|---|
| Cottonwood Ck - Blacktail | 6/1/2004 | 33 | 100% W | |
| Jones Ck | 10/30/2001 | 25 | WxYxR; some individuals exhibited Y alleles, one exhibited R alleles | |
| Bean Ck | 10/29/2001 | 54 | 98% W x 2% R; only 1 fish displayed R alleles | |
| Bear Ck | 10/29/2001 | 53 | 100% W | |
| Wall Ck | 10/19/2001 | 25 | 99% W x 1% R | |
| NF English George | 10/18/2001 | 9 | WxRxY, too few fish to discern percentages | |
| SF English George Ck | 10/18/2001 | 23 | 80.4%Wx19.6%Y swarm | |
| WF Wilson | 10/1/2001 | 48 | 100% W | |
| | | | | |

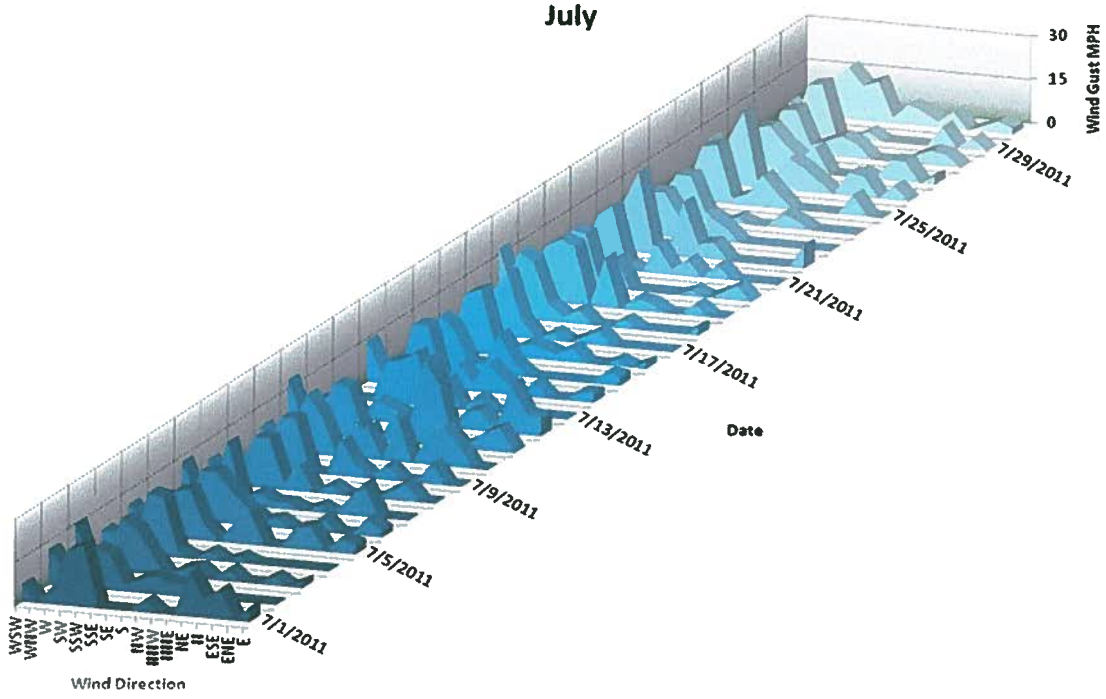
# Appendix I

## Hebgen Reservoir wind speed and gust data by date, 2011

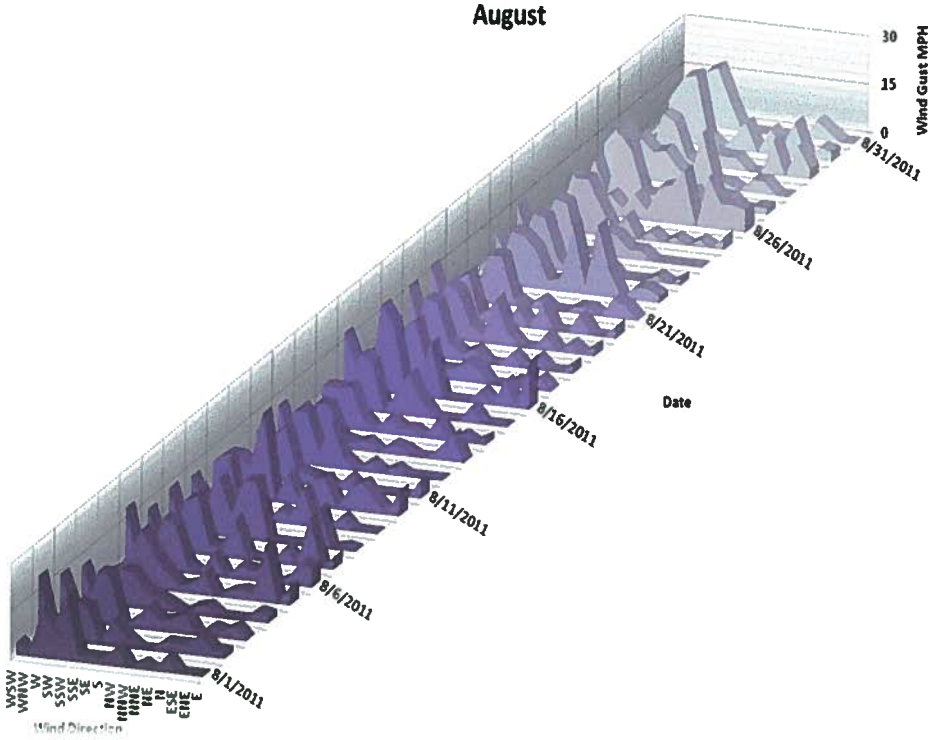
## June


30
15
0
Wind Gusts MPH
6/29/2011
6/25/2011
6/21/2011
6/17/2011
6/13/2011
6/9/2011
6/5/2011
Date
WSW
WNW
W
SW
SSW
SSE
SE
S
NW
NNW
NNE
NE
N
ESE
ENE
E
Wind Direction

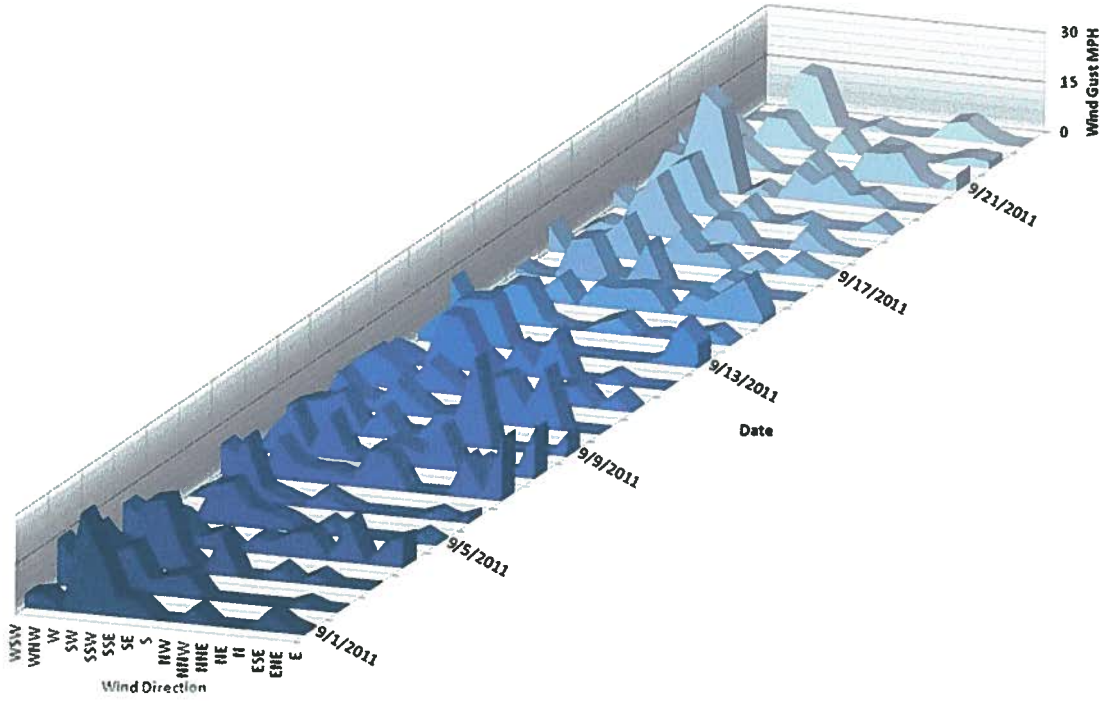
## July


30
15
0
Wind Gust MPH
7/29/2011
7/25/2011
7/21/2011
7/17/2011
7/13/2011
7/9/2011
7/5/2011
7/1/2011
Date
WSW
WNW
W
SW
SSW
SSE
SE
S
NW
NNW
NNE
NE
N
ESE
ENE
E
Wind Direction

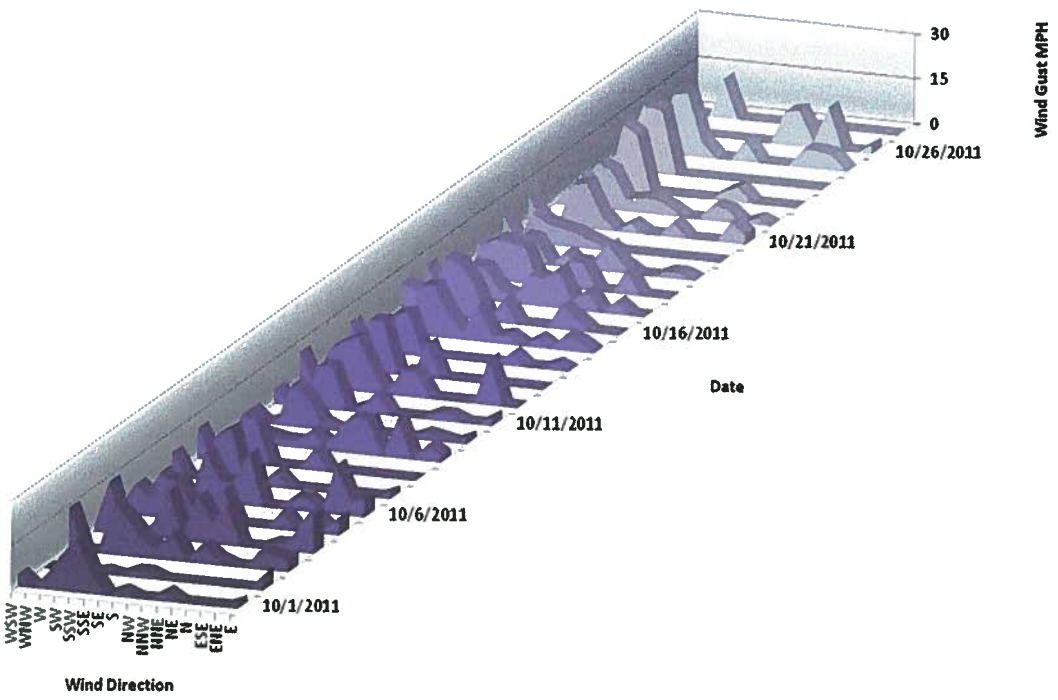
## August




## September



# October


30
15
0
Wind Gust MPH
10/26/2011
10/21/2011
10/16/2011
Date
10/11/2011
10/6/2011
10/1/2011
VVSW
VW
VWNW
W
WNW
WSW
SW
SSW
SSE
S
SE
ESE
E
Wind Direction