JARBIDGE RIVER WATERSHED

STREAM TEMPERATURE MONITORING

1999

Selena J. Werdon
U.S. Fish and Wildlife Service
Nevada Fish and Wildlife Office
1340 Financial Blvd., Suite 234
Reno, Nevada 89502
PRELIMINARY DRAFT: December 1, 2000

Acknowledgments

Landowner Chet Brackett pennitted access to several miles of Dave Creek on his private land. Dr. Jason Dunham (fonnerly with the Department of Biology and Biological Resources Research Center at the University of Nevada-Reno) provided 33 calibrated and pre-programmed Onset® temperature loggers and guidance on study design. Stu Chamberlain (fonnerly with the U.S. Forest Service in Elko, Nevada) set loggers at two additional stations on Dave Creek in the Humboldt-Toiyabe National Forest and the resulting temperature data are also included in this report. Survey crew members were John Branstetter, Stephanie Byers, Stu Chamberlain, Phil Delphey, Jim Harvey, Steve Hokansson, Sam Lohr, Dennis Mackey, Stewart Reinbold, Kristin Schuring, and Selena Werdon. Richard Duncan also assisted with logger removal.

Introduction

The bull trout *(Salvelinus conjluentus)* population in the Jarbidge River Basin of Idaho and Nevada was federally listed as threatened under the Endangered Species Act of 1973, as amended, on April 8, 1999. The Jarbidge River Basin represents the southernmost remaining range of bull trout in the United States. This bull trout population is isolated from other bull trout populations in the Snake River Basin by over 240 kilometers (km) [150 miles (mi)] of seasonally unsuitable habitat and several impassable dams.

Bull trout are most often found in coldwater streams, although individual fish can occur throughout larger river systems (Fraley and Shepard 1989; Rieman and McIntyre 1993, 1995; Buchanan and Gregory 1997; Rieman *et al.* 1997). Water temperatures above 15° C (59° F) are believed to limit bull trout distribution and to at least partially explain the generally patchy distribution of occupied habitat within a given watershed (Fraley and Shepard 1989; Rieman and McIntyre 1995). Bull trout reportedly prefer water temperatures around 10-12° C (50-53.6° F) in migratory corridors, but will migrate through stream reaches with higher water temperatures, especially those with thennal refugia such as cold tributary stream confluences (McPhail and Murray 1979; Buchanan and Gregory 1997; Swanberg 1997).

Across their range, resident and migratory bull trout typically spawn from August to November. However, fluvial and adfluvial bull trout often begin migrating to spawning areas earlier in the year, likely in response to increasing water temperatures (Fraley and Shepard 1989; Swanberg 1997). Bull trout spawning areas are often associated with coldwater springs, areas of groundwater infiltration, and the coldest streams in a particular watershed (Goetz 1989; Pratt 1992; Rieman and McIntyre 1993, 1996; Rieman *et al.* 1997). Spawning habitat typically consists of low gradient « 2 percent) stream reaches with loose, clean gravel/cobble substrate and water temperatures of 4 to 10° C (39 to 51 ° F) in the fall (Fraley and Shepard 1989; Goetz 1989; Pratt 1992; Rieman and McIntyre 1996; Montana Bull Trout Scientific Group 1998). Optimum survival (80-95 percent) of bull trout eggs during incubation is reported at constant temperatures of 2-4° C (35.6-39.2° F); survival can be 20 percent or less at temperatures of 8-10° C (46.4-50° F) (McPhail and Murray 1979; Weaver and White 1985).

Research has shown that under laboratory conditions, \20 C *(53.6°* F) is near optimum for both growth and survival of juvenile bull trout fed to satiation (McMahon *et al.* 1998, 1999). However, juvenile bull trout in the wild likely have higher growth rates at lower temperatures (8-12° C, *46.4-53.6°* F) because of the low productivity and reduced food availability of headwater stream reaches (McMahon *et al.* 1998, 1999). Juvenile bull trout rearing temperatures of 4 to 10° C (39 to 51 ° F) have been reported as optimal (Buchanan and Gregory 1997). The upper incipient lethal temperature (50 percent mortality) for juvenile bull trout is approximately 21 ° C *(69.8°* F) (McMahon *et al.* 1998,1999).

In this study, we gathered water temperature and limited bull trout distribution data to increase the general knowledge of habitat suitability and use by bull trout in selected streams within the Jarbidge River Basin. This study did **not** involve counting individual fish or gathering data for bull trout population estimates.

Methodology

The U.S. Fish **and** Wildlife Service (Service) selected three known occupied bull trout streams in the Jarbidge River Basin for this study, specifically the West Fork of the Jarbidge River and Slide and Dave Creeks, which are both tributary to the East Fork of the Jarbidge River. Water temperature data were also collected from a single station on lower Pine Creek, a tributary to the West Fork of tbe Jarbidge River. Bull trout are known to occur in Pine Creek, but no fish surveys were associated with this single station. Two tributaries to Slide Creek (Tributary A and God's Pocket Creek) were surveyed for fish, incidental to Slide Creek station surveys. Figure 1 is a map of the study area.

We attempted to initially document water temperatures within a reach of each of the three study streams that encompassed both occupied (bull trout present) and unoccupied (bull trout absent) habitat. The study protocol called for locating a water temperature station at the downstream limit of bull trout distribution and establishing the remaining stations upstream and downstream of this location with approximately 600-meter (m) [1,968-foot (ft)] spacing between stations, for a total of 10 water temperature stations per stream. Station spacing was estimated by pacing or use of a 100-m (328.1-ft) tape. A single air temperature station was established for each stream at a shaded location near the mid-point of the stream reach (e.g., between Stations 5 and 6).

Stream and air temperature data were collected using two models of Onset® Computer Corporation temperature loggers. HOBO® H8 Temp Logger models with internal sensors were used at all Service stations on the West Fork of the Jarbidge River and Slide and Dave Creeks. StowAway® XTI model loggers with internal sensors were used by the U.S. Forest Service (USFS) for two Dave Creek stations and the Service's Pine Creek station. StowAway® XTI loggers were set to record at I-hour intervals, while HOBO® loggers were set to record at intervals. All loggers were placed in locking plastic bags and sealed inside submersible polycarbonate screw top cases along with desiccant packs. The plastic bags, and inside and outside of the cases were labeled with the stream name and station number. The cases were

secured with metal hose clamps to a piece of 1.3-centimeter (cm) [0.5-inch (in)] rebar. They were submerged in the deepest flowing water available at each station with the rebar either anchored into the substrate or streambank, if possible, otherwise they were anchored with rocks.

Stations were marked with fluorescent flagging tape, except in areas of high public use. Ambient light and riparian vegetation density permitting, color photographs of each station were taken once the logger was in place to assist in logger relocation. Military Precision Lightweight Global Positioning System Receivers (PLGRs) were used to record station UTM coordinates and elevation, if satellites could be acquired to obtain an accurate reading (Appendix A). PLGR station data were downloaded onto a computer and plotted on topographic maps. Where canyon topography prevented PLGR use, station locations and elevations were estimated based on the distance from plotted known station locations.

Survey crews primarily consisted of a snorkeler and a data recorder, but occasionally were assisted by an additional biologist. Initial snorkel survey locations were selected based upon bull trout presence/absence distribution data from August 1998 surveys (Johnson 1999). Survey crews snorkeled stream reaches during the day, moving in an upstream direction to detect the downstream limit of bull trout distribution in each of the three selected streams, and thereby establish station spacing. High flows (approximately 991-1,132 liters per second; 35-40 cubic feet per second) on the West Fork of the Jarbidge River and resulting underwater turbulence prevented reliable visual detection of bull trout presence/absence during the initial survey, so these stations were established using the Jarbidge Wilderness boundary as the center of this stream reach. On June 30, 1999, water temperature loggers were set at 10 stations on both the West Fork of the Jarbidge River and Slide Creek, and at the upper seven stations on Dave Creek. An air temperature station was established for all three study stream reaches that same day. On July I, 1999, a water temperature logger was set at one station on Pine Creek. The USFS set two loggers on upper Dave Creek on July 30, 1999. Loggers at the Service's three downstream stations on Dave Creek (Stations 8-10) were set on August 23,1999.

The protocol for subsequent daytime snorkel surveys was to begin the survey 150 m (492 ft) downstream of a station and snorkel upstream for a total stream distance of 300 m (984 ft) or until a bull trout was detected. Once a bull trout was observed or 300 m (984 ft) was reached, the survey crew moved to the next station. Snorkel surveys of various stations occurred on June 30, August 24, and October 14, 1999.

All loggers were removed from the streams for the winter to avoid displacement and loss during spring high flows, and to download the temperature data. Loggers on the West Fork of the Jarbidge River were removed on October 5 (Stations 1-5 and Air Station), and October 6, 1999 (Stations 6-10). The Pine Creek logger was also removed on October 6, 1999. All Slide Creek loggers were removed on October 14, 1999. Loggers on Dave Creek at Service Stations 1-10 and the Air Station were removed on October 15,1999; the USFS removed their two Dave Creek loggers on October 6, 1999.

Results

West Fork ofthe Jarbidge

During the June 30 to October 5-6, 1999 monitoring period, air temperatures along the West Fork of the Jarbidge River ranged from daytimc highs of28.7" C (83.7 ₀ F) on July 23 and 27 to a nighttime low of _7.3⁰ C (18.9" F) on September 28, 1999 (Table I and Appendix B). Maximum daily high water temperatures increased gradually in a downstrcam direction among the 10 stations, except at Station 8 (Table 1). Data from Station 8 recorded before August 24,1999, were excluded from consideration because the logger was found barely submerged on that date and measurements may have been directly influenced by air temperatures and sun exposure. The Station 8 logger was relocated early that day approximately 2 m (6.6 ft) downstream in deeper water. Maximum daily high water temperatures primarily occurred in late August at all 10 stations and generally corresponded with increased daily high air temperatures (Table I and Appendix B). Minimum daily low water temperatures primarily occurred in late September and cOITesponded with minimum daily low air temperature dates (Table I and Appendix B). Water temperatures in the West Fork of the Jarbidge River exceeded 15" C (59 ₀ F) at three stations (8-10) during the monitored period.

Table I. West Fork of the Jarbidge River water and air temperature logger station elevations and maximum and minimum daily high and low temperatures recorded in 1999 (a = Data before 8-24-99 was excluded).

Station #	Elevation (m/ft)	Daily High Temp." C (" F) / Dale(s)		Daily Low Temp." C (" F) / Datc(s)	
		Maximum	Minimum	Maximum	Minimum
1	2,248 / 7,370	*14.1* (57.4) / 8-24	5.0 (41) /	to.2 (50.4) / 8-24	1.2 (34.2) /
2	2,176/7,134	141 / 8-24	(40.3) / 9-28	1112 (50.4) / 8-23,24	(34.9) / 9-28
3	2,153 /7,058	14.1 / 8-23.24	4.6 (40.3) / 9-28	10.6 (51 .1) / 8-24	1.6 (34.9) / 9-28
4	*2.14117.019*	14.4 (57.9) /	5.0(41)/9-28	106 (51.1) / 8-23,24	1.6 (34.9) / 9-28
5	2.134 ! 6,997	14.5 (58.1) / 8-24	5.0(41)/9-28	10.6 / 8-23,24	1.6 (34.9) / 9-28
t,	*1,!* 05/6,901	14.9 / 8-24	5.8 (42.4) / 9-28	11.4 / 8-24	2.5 (36.5) /
7	*2,079* J6,815	14.9 / 8-24	(43.9) /	11.4 (52.5) / 8-24	3.3 (37.9) / 9-28,29, 10-3
8ª	2,072 /	15.6 (60.2) /8-25,29	7.4 (45.3)! 9-28	11.4 (52.5) / 8-25	2.9 (37.2) / 9-28
9	2,072 /6,793	15.2 (59.4) / 8-23,24	7.0 (44.6)! 9-28	118 (53.2) / 8-24	3.7 (3B.7) / 9-28,29, 10-3
10	2,054/6,733	15.2 *17-27,* 8-20,23,24	7.0 (44.())! 9-28	11.8 (53.2) / 8-23,24	3.3 (37.9) / 9-28
Air	2,122 / 6,962	(83.7) *i 7-23,27*	7.0 (44.()) / 9-3	12.2(54)/8-3	-7.3 (18.9)/9-28

On June 30,1999, a single (12.7 cm, 5 in) bull trout was observed in the West Fork of the Jarbidge River within Station 1. The water temperature at Station 1 when the logger was set (at 1500-1530 hrs) was 10.2° C (50.4° F), with a low temperature that night of 5° C (41 ° F). Native Interior redband trout *(Oncorhynchus mykiss gibbsi)* were observed at Stations 1,4,5, and 6. Stations 8, 9, and 10 were not surveyed.

On August 24, 1999, four bull trout were observed within Station 1, all of which were greater than 20.3 cm (8 in) totallength. Three bull trout were also observed within Station 2; two greater than 20.3 cm (8 in) and one greater than 30.5 cm (12 in) totallength. Water temperatures at Stations 1 and 2 that day were the highest recorded for the entire study period, and both stations ranged from 10.2-14.1° C (50.4-57.4° F). Redband trout were observed at all 10 stations.

Slide Creek

During the June 30 to October 14,1999 monitoring period on Slide Creek, recorded maximum daily high air temperatures were invalid due to the logger experiencing sun exposure. However, nighttime lows ranged from -6.8 to 13.7° C (19.8 to 56.7° F) (Table 2 and Appendix C).

Maximum daily high water temperatures were consistent at the upper three stations, decreased downstream at Stations 4 through 6, and increased again at Stations 7 to 10 (Table 2). Maximum water temperature data from Stations 5, 6, 8, and 9 recorded before August 24, 1999, were excluded from consideration because the loggers were found partially or entirely out of the water on that date, and measurements may have been directly influenced by air temperatures and/or sun exposure. However, data from other water temperatures recorded at Stations 4 through 9 after the four suspect loggers were reset have a similar pattern (Table 2).

On June 30, 1999, a single juvenile (8.9 cm, 3.5 in) bull trout was observed in Slide Creek between Stations 5 and 6. This fish was 50-150 m (164-492 ft) upstream of the Tributary A confluence. The water temperature recorded at both Stations 5 and 6 when the loggers were set (at 1730-1945 hrs, MDT) was 10.2° C (50.4 ° F), with a low temperature that night of 5.8° C (42.4 ° F). In addition, two juvenile (10.2 cm, 4 in) bull trout were observed in Tributary A, but no temperature data were recorded for this stream. Redband trout were observed at Stations 3 and 9, and in Tributary A. Stations 1,2,4-8, and 10 were not surveyed. No fish were observed in the lower 150 m (492 ft) of God's Pocket Creek, and no temperature data were recorded for this stream.

On August 24, 1999, bull trout were observed within the survey reaches at Stations 2 through 10 on Slide Creek, with daily water temperature ranges and approximate fish total lengths as follows: Station 2: 9.4-13.3° C (49-56° F), 17.8 cm (7 in); Station 3: 9.8-12.9° C (49.6-55.2 ° F), 15.2 cm (6 in); Station 4: 9.4-12.9° C (49-55.2 ° F), 15.2 cm (6 in); Station 5: 10.2-12.5° C (50.4-54.6° F), 15.2 cm (6 in); Station 6: 9.8-12.5° C (49.6-54.6° F), 15.2 cm (6 in); Station 7: 10.2-12.9° C (50.4-55.2 ° F), 12.7 cm (5 in); Station 8: 10.2-14.1° C (50.4-57.4 ° F), 15.2 cm (6 in);

Station 9: 10.2-14.1° C (50.4-57.4° F), 19 em (7.5 in); and Station 10: 10.6-14.1° C (51-57.4° F), 15.2 em (6 in). Redband trout were observed at all 10 stations, as well as in God's Pocket Creek.

Table 2. Slide Creek water and air temperature logger station locations and maximum and minimum daily high and low temperatures recorded in 1999 (a = Data recorded on or before 8-24-99 was **excluded; b = Logger in sun).**

Station #	Elevation (m/ft)	Daily High Temp. ° C (° F) / Date(s)		Daily Low Temp. ° C (° F) / Dale(s)	
		Maximum	**Minimum**	**Maximum**	**Minimum**
I	*2,373/7,786*	*13.3 (55.9)/7-6,12,27,* 8-24	5.0 (41) *110-6*	8.2 (46.8) *18-21 ,22*	1.6 (34.9) *19-28*
2	*2,30817,572*	13.3 (55.9) *17-12,27,* 8-19,24	*4.6 (40.3)/10-6*	9.4 (48.9) *18-3,23,24*	1.2 (34.2) *19-28*
3	2,263 *17,425*	13.3 (55.9) *17-12,27,* 8-19	4.6 (40.3) *19-27,28,* 10-6	9.8 (49.6) *18-23,24*	1.2 (34.2) *19-28*
4	2,222 *17,290*	12.9 (55.2) *17-6,12,13,* 8-24	3.3 (37.9) *19-28*	9.4 (48.9) *18-23,24*	0.3 (32.5) *19-28*
5'	2,203 *17,228*	11.8 (53.2) *18-25*	*3.3 (37.9)/9-27,28*	8.6 (47.6) *18-25,27,30*	0.3 (32.5) *19-28*
6'	*2,168/7,113*	11.8 (53.2) *18-25*	3.3 (37.9) *19-27,28*	9.0 (48.2) *18-30*	0.7 (33.3) *19-28*
7	*2,136/7,008*	12.9 (55.2) *18-20,23,24*	3.3 (37.9) *19-28*	10.2 (50.4) *18-23,24*	0.7 (33.3) *19-28*
8	*2,106/6,910*	*14.1 (57.4)/8-24*	4.2 (39.6) *19-28*	9.4 (49.0) *18-25,27,30*	0.7 (33.3) *19-28*
9	*2,077 16,815*	*14.1 (57.4)/8-24*	*4.6 (40.3)/9-27,28,* 10-6	9.4 (49.0) *18-25,30*	0.7 (33.3) *19-28*
10	*2,053/6,736*	*14.1 (57.4)/8-24*	4.6 (40.3) *19-28*	10.6 (51.1) *18-23,24*	1.2 (34.2) *19-28*
Air[b]	*2,182/7,159*	----------	5.0 (41) *110-6*	*13.7 (56.7)17-14*	-6.8 (19.8) *19-28*

On October 14, 1999, one adult bull trout was observed within the Station 1 reach and a single (20 em, 7.9 in) bull trout was observed within the Station 8 reach. Water temperatures on that day ranged from 3.3-11° C (38-51.8 ° F) at Station 1 and 2.5-5.0° C (36.4-41 ° F) at Station 8, although the Station 8 logger was pulled at 1130 hrs (MDT). The high temperature at Station 8 the previous day was 6.6° C (44° F). Stations 2-7 and 9 were not surveyed for fish.

Dave Creek

During the June 30 to October 15, 1999 monitoring period, recorded air temperatures along Dave Creek ranged from a daytime high of28.7° C (83.7 ° F) on July 6 to a nighttime low of -6.8° C (19.8° F) on September 27, 1999 (Table 3 and Appendix D). Maximum daily high water temperatures increased gradually in a downstream direction among the upper four stations (USFS 1 and 2, and Stations 1 and 2). Data from Stations 3-6 and 9 recorded on or before August 24, 1999, were excluded from consideration because the loggers were found partially or entirely out ofthe water or in a stagnant pool on that date due to greatly decreased flows and channel

movement. All temperature data for Station 7 and a portion of the data for Station 6 (July 22-October 15, 1999) were lost due to the logger cases flooding.

On June 30, 1999, one adult bull trout was observed at Station 5. Two additional adult bull trout were also observed separately between Stations 4 and 5. Water temperatures on that day ranged from 5-14.9° C (41-58.8° F) at Station 4 and 5.4-13.7° C (41.8-56.6° F) at Station 5. Stations 1-4 and were not surveyed; Stations were not established until August 1999.

Table 3. Dave Creek water and air temperature logger station elevations and maximum and minimum daily high and low temperatures recorded in 1999 (a = Data recorded on or before 8-24-99 was excluded; b = Logger flooded, partial or total data loss).

Station #	Elevation (mlft)	Daily High Temp. ° C (° F) / Date(s)		Daily Low Temp. ° C (° F) / Date(s)	
		Maximum	Minimum	Maximum	Minimum
USFS1	~2,225 /	13.1 (55.6) / 8·19,23	5.1 (41.2)/9-27,28	7.7 (45.9) / 8-23,24	0.4 (32.7) / 9-28
USFS2	-2,150/	14.5 (58.1)/8-19	6.2 (43.2) / 9-27,28	8.4(47.1)/8-24	0.0 (32) / 9-28
1	2,106 / 6,906	16.4(61.5)/8-19	5.4 (41.7) /10-6	9.0 (48.2) / 8-23,24	-0.2 (31.6) / 9-28
2	2,089/6,849	17.1 (62.8)17-27, 8-21,24	5.8 (42.4) /10-6	9.4 (48.9) / 8-23,24	0.3 (32.5) / 9-28
3'	2,083/6,831	17.5 (63.6)/ 8-26	5.8 (42.4) /10-6	10.2 (50.4) / 8-26	-0.2 (31.6) / 9-28
4'	2,052/6,728	17.9 (64.2) / 8-26	5.8 (42.4)/ 10-6	9.4 (49.0) / 8-26,29	-0.2 (31.6) / 9-28
5'	2,020/6,623	17.9 (64.2) / 8-26	5.8 (42.4)/ 10-6	10.2 (50.4) / 8-26	0.3 (32.5) / 9-28
6[a,b]	2,004 / 6,572	17.1 (62.8)17-12	13.7 (56.7)/7-4	9.8 (49.6)17-14	3.7 (38.7) 17-5
7[a, b]	1,990 / 6,524	.....	----------	.....	----------
8	1,938/6,355	17.5 (63.5) /8-24,26	6.2 (43.2) / 9-27,28, 10·6	12.2 (54.0) /8-24	0.3 (32.5) / 9-28
9'	1,920/6,296	16.8 (62.2)/ 8-26	5.4 (41.7) / 9-28	12.5 (54.6) / 8-23	0.3 (32.5) /9-28
10	1,905 / 6,245	16.8 (62.2)/ 8-24	5.0 (41) / 9-28	12.9 (55.2) / 8-24	0.3 (32.5) / 9-28
Air	2,006 / 6,578	28.7 (83.7)17-6	7.4 (45.3) / 9-27,10-6	15.6 (60.1) / 7-14	-6.8 (19.8) / 9-27

On August 24,1999, one bull trout each was observed at Stations 2 and 3. Water temperatures on that day ranged from 9.4-17.1° C (49-62.8° F) at Station 2 and 9.8-17.5° C (49.6-63.6° F) at Station 3. Redband trout were present at Stations 1-5 and 9-10. Stations 6-8 were not surveyed.

Pine Creek

No air temperature station was established on Pine Creek, but the West Fork of the Jarbidge River Air Station was within 2.4 km (1.5 mi) of Pine Creek Station 1. During the July 1 to

October 6, 1999 monitoring period for Pine Creek, air temperatures along the West Fork of the Jarbidge River ranged from daytime highs of 28.7° C (83.7 ° F) on July 23 and 27 to a nighttime low of -7.3° C (18.9° F) on September 28, 1999 (Table 1 and Appendix B). Daily water temperature fluctuations at the Pine Creek station corresponded closely with air temperatures at the West Fork of the Jarbidge River Air Station (Table 1 and Appendices B and E). Water temperatures were recorded at only a single station near the mouth of Pine Creek, so no instream temperature trend data are available (Table 4 and Appendix E). Although no fish surveys were made at this station, water temperatures on or near the dates of other stream surveys were: 7.0-14.5° C (44.5-58.1 ° F) on July **1,** 1999; 10.6-15.9° C (51.1-60.6° F) on August 24, 1999; and 5.1-8.1° C (41.2-46.5° F) on October 5-6,1999.

Table 4. Pine Creek water temperature logger station elevation and maximum and minimum daily high and low temperatures recorded in 1999.

Station #	Elevation (m/ft)	Daily High Temp. "C (° F) / Date(s)		Daily Low Temp. " C (° F) / Date(s)	
		Maximum	Minimum	Maximum	Minimum
1	-2,020/6.628	16.6 (61.9) *17-27,* 8-1,20	6.2 (43.2) / 9-28	12.0 (53.6) / 8-23,24	1.6 (34.9) / 9-28

References

Buchanan, D.M., and S.V. Gregory. 1997. Development of water temperature standards to protect and restore habitat for bull trout and other cold water species in Oregon. Pages 1-8 *in* Mackay, W.C., M.K. Brewin, and M. Monita, eds. Friends of the Bull Trout Conference Proceedings.

Fraley, J.J., and B.B. Shepard. 1989. Life history, ecology and population status of migratory bull trout *(Salvelinus confluentus)* in the Flathead Lake and River system, Montana. Northwest Science 63(4):133-143.

Goetz, F. 1989. Biology of the bull trout, *Salvelinus confluentus,* literature review. Willamette National Forest, Eugene, OR.

Johnson, G.L. 1999. The status of the bull trout in Nevada. Nevada Division of Wildlife, Reno, NY, 17pp.

McMahon, T., A. Zale, J. Selong, and R. Barrows. 1998. Growth and survival temperature criteria for bull trout. Annual Report 1998. Montana State University and USFWS Bozeman Fish Technology Center, Bozeman, MT. 12 pp.

McMahon, T., A. Zale, J. Selong, and R. Barrows. 1999. Growth and survival temperature criteria for bull trout. Annual Report 1999 (Year Two). Montana State University and USFWS Bozeman Fish Technology Center, Bozeman, MT. 26 pp.

McPhail, J.D., and C.B. Murray. 1979. The early life history and ecology of dolly varden *(Salvelinus malrna)* in the upper Arrow Lakes. Department of Zoology and Institute of Animal Resources, University of British Columbia, Vancouver, British Columbia.

Montana Bull Trout Scientific Group. 1998. The relationship between land management activities and habitat requirements of bull trout. Montana Bull Trout Restoration Team, Helena, MT. 78 pp.

Pratt, K.L. 1992. A review of bull trout life history. Pages 5-9 *in* Howell, P.J., and D.V. Buchanan, eds. Proceedings of the Gearhart Mountain Bull Trout Workshop. Oregon Chapter of the American Fisheries Society, Corvallis, OR.

Rieman, B.E., and J.D. McIntyre. 1993. Demographic and habitat requirements for conservation of bull trout. USDA Forest Service, Intermountain Research Station. General Technical Report lNT-302.

Rieman, B.E., and J. D. McIntyre. 1995. Occurrence of bull trout in naturally fragmented habitat patches of varied size. Transactions of the American Fisheries Society 124

(3):285-296.

Rieman, B.B., and J.D. McIntyre. 1996. Spatial and temporal variability in bull trout redd counts. North American Journal of Fisheries Management 16:132-146.

Rieman, B.B., D.C. Lee, and R.F. Thurow. 1997. Distribution, status and likely future trends of bull trout within the Columbia River and Klamath River basins. North American Journal of Fisheries Management 17: 111-1125.

Swanberg, T. 1997. Movements of and habitat use by fluvial bull trout in the Blackfoot River, Montana. Transactions of the American Fisheries Society 126:735-746.

Weaver, T.M., and R.G. White. 1985. Coal Creek fisheries monitoring study No. III. Quarterly progress report. Montana State Cooperative Fisheries Research Unit, Bozeman, MT.

APPENDICES

Appendix A. Locations of water and air temperature stations on the West Fork of the Jarbidge River, Slide Creek, Dave Creek, and Pine Creek in 1999.

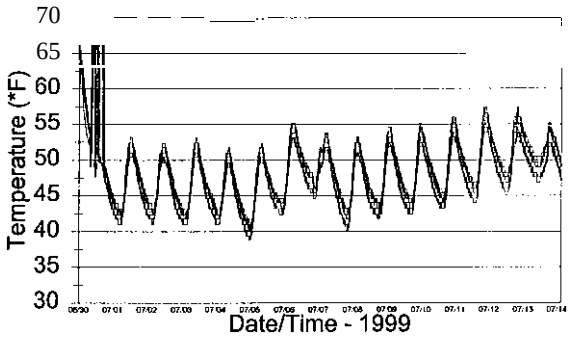
	West Fork of the Jarbidge River		Slide Creek'		Dave Creek		Pine Creek	
Station #	Latitude	Longitude	Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
USFSI	N/A	N/A	N/A	N/A	N41"55'_ "	W115°21'_ "	N/A	N/A
USFS2	N/A	N/A	N/A	N/A	N 41° 55'_ "	W 115° 21'_ "	N/A	N/A
1	N 41' 48' 28.66"	W 115' 24' 24.60"	N 41° 50'24.35"	W 115' 15' 41.56"	N 41° 55' 03.07"	W 21' 24.96"	N/A	N/A
2	N41"48'36.91"	W 24' 24.16"	N 50' 29.29"	W 115" 15' 29.67"	N 41' 55' 19.29"	W 21' 37.88"	N/A	N/A
3	N41°48'46.86"	W 115' 24' 31.85"	N 50' 1.24"	W 115' 16' 07.75"	N 55' 36.02"	W 21' 48.88"	N/A	N/A
4	N 4}048' 51.38"	W 115° 24' 32.49"	N41049'54.81"	W 115° 16' 25.98"	N 41° 55' 53.90"	W 115" 21' 56.71"	N/A	N/A
5	N 48' 54.54"	W 115° 24' 35.93"	N 41° 49' 56.85"	W 115° 16' 47.20"	N 56' 13.49"	W 22' 05.38"	N/A	N/A
6	N41"49'6.19"	W 115° 24' 46.78"	N4}050'02.86"	W 115' 17' 04.18"	N 41° 56' 31.78"	W 22' 08.74"	N/A	N/A
7	N 41°49' 15.50"	W 115" 24' 53.74"	N 50' 13.53"	W 115° 17' 20.88"	N 41° 56' 50.57"	W 115" 22' 11.85"	N/A	N/A
8	N4}049'26.07"	W 115° 25' 02.43"	N 41° 50' 25.09"	W 115° 17' 35.90"	N410 57' 09.61"	W 115" 22' 09.97"	N/A	N/A
9	N 41° 49' 34.24"	WI15'25'10.71"	N 50' 32.14"	W 115° 17' 54.88"	N 57' 29.24"	W 115" 22' 10.68"	N/A	N/A
10	N 41° 49' 45.02"	W 25' 16.16"	N 41° 50' 49.17"	W 115° 18' 04.04"	N 41° 57' 48.23"	W 22' 08.84"	N 41° 50' 3._ "	W 115° 25' 31 _ "
Air	N4}048'58.09"	W 115° 24' 42.80"	N 50'00.21"	W llSo 16' 56.87"	N 41° 56'22.32"	W 115" 22' 08.15"	N/A	N/A

* - PLGR datum was erroneously set on IRL.

APPENDIXB

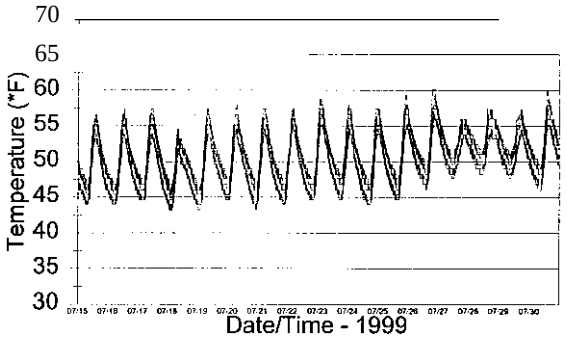
West Fork Jarbidge River

All Stations



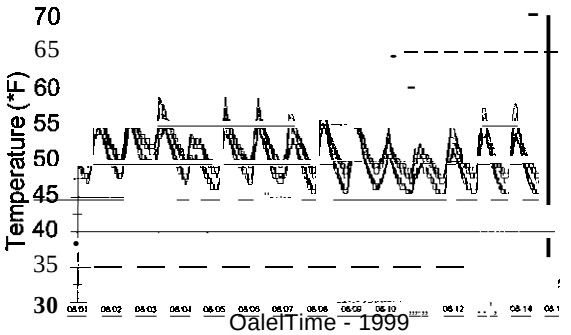
West Fork Jarbidge River

All Stations



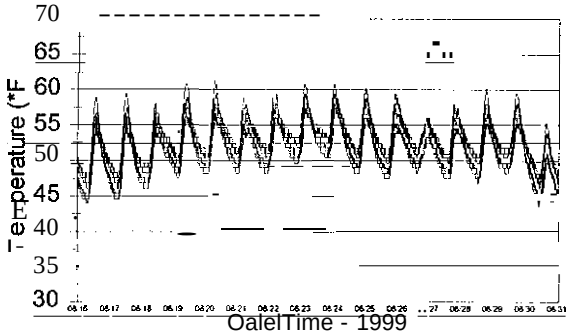
West Fork Jarbidge River

All Stations



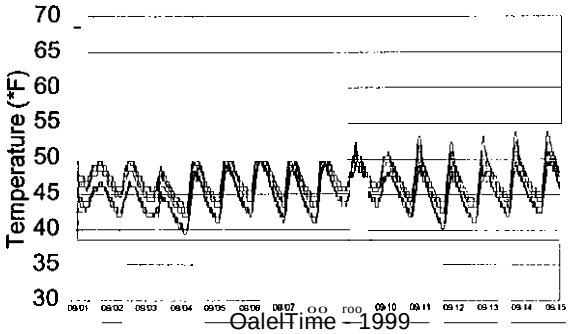
West Fork Jarbidge River

All Stations



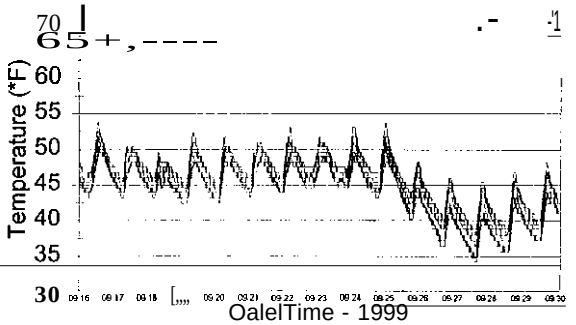
West Fork Jarbidge River

All Stations



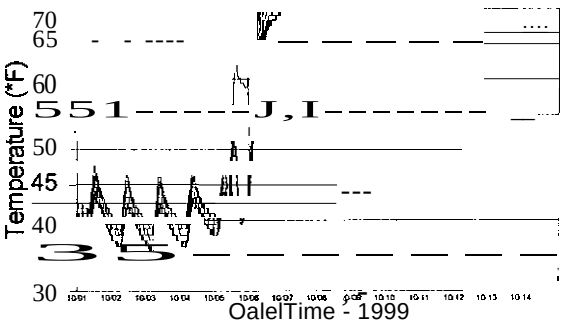
West Fork Jarbidge River

All Stations



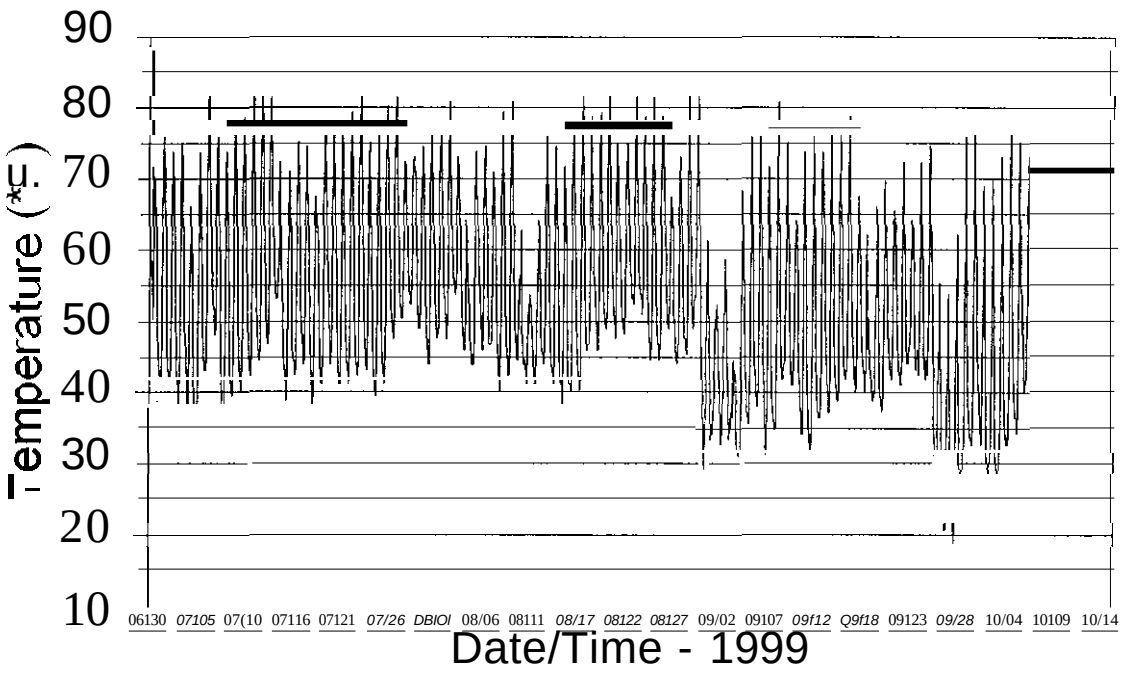
West Fork Jarbidge River

All Stations



West Fork Jarbidge River

Air Station - #195869

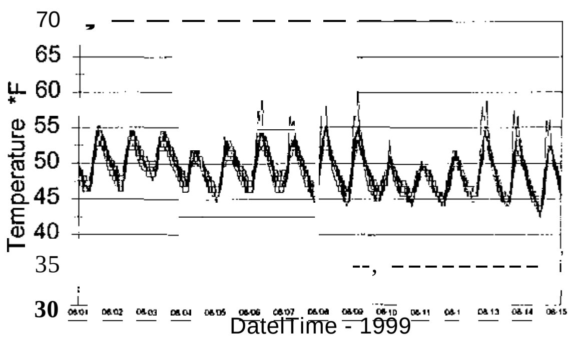


APPENDIXC

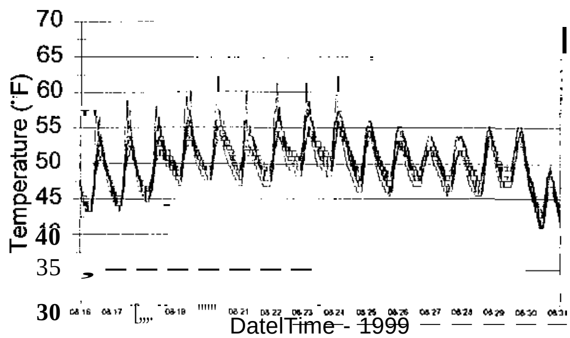
Slide Creek
All Stations

Slide Creek
All Stations

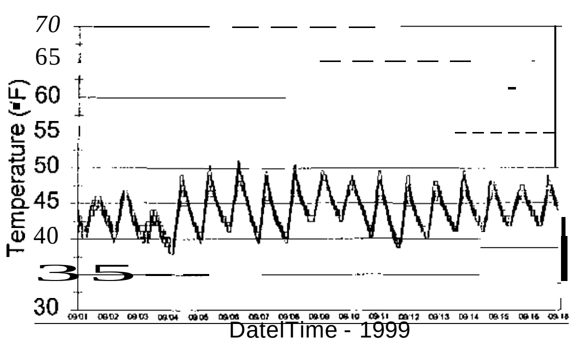
Slide Creek
All Stations



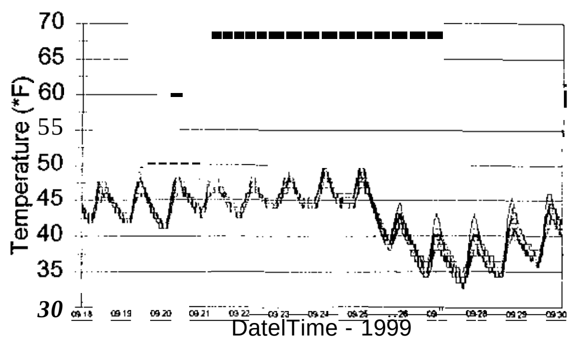
Slide Creek
All Stations



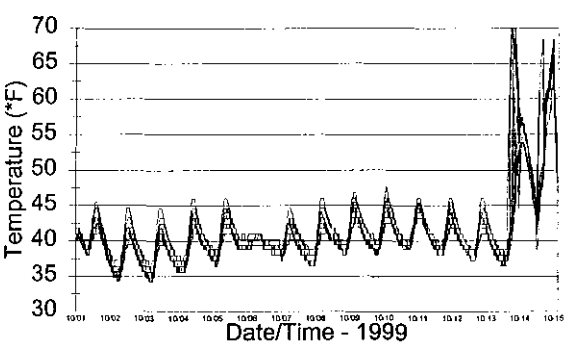
Slide Creek
All Stations



Slide Creek
All Stations

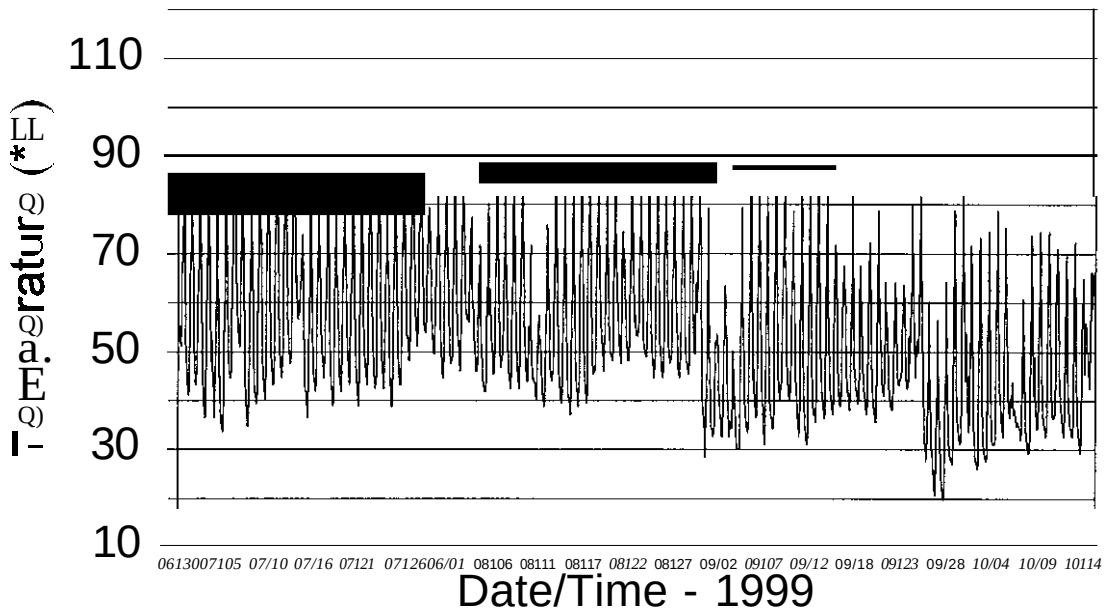


Slide Creek
All Stations



Slide Creek

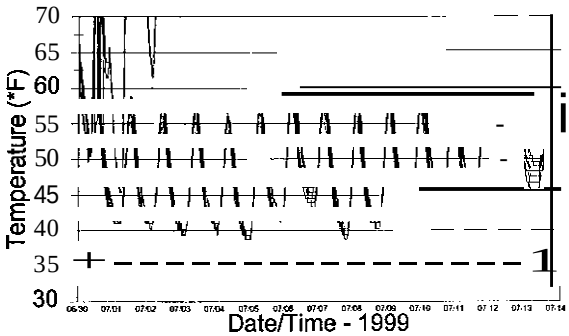
Air Station - #195561



APPENDIXD

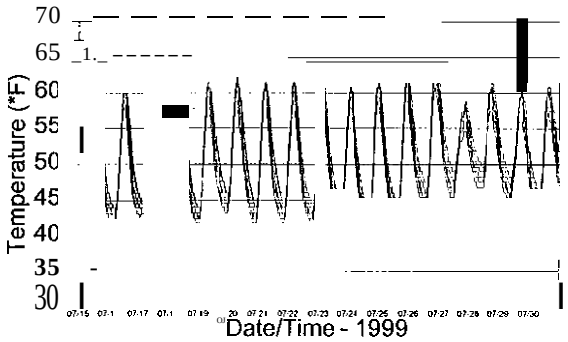
Dave Creek

All Stations



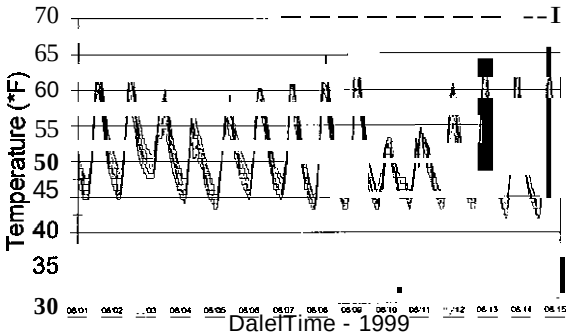
Dave Creek

All Stations



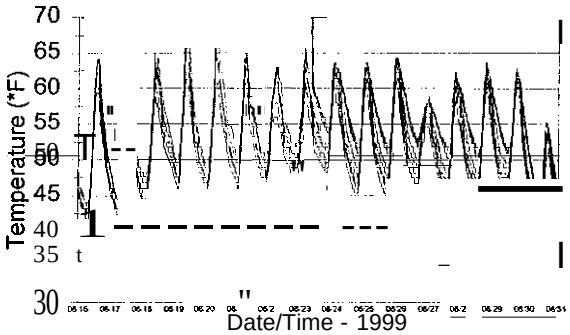
Dave Creek

All Stations



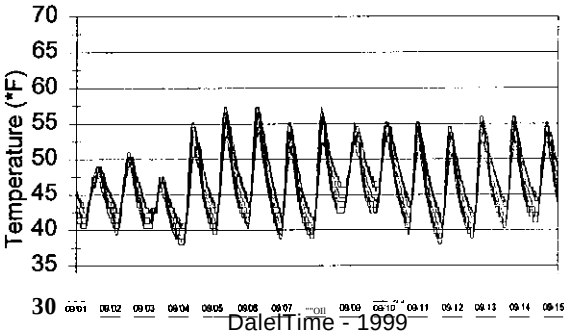
Dave Creek

All Stations



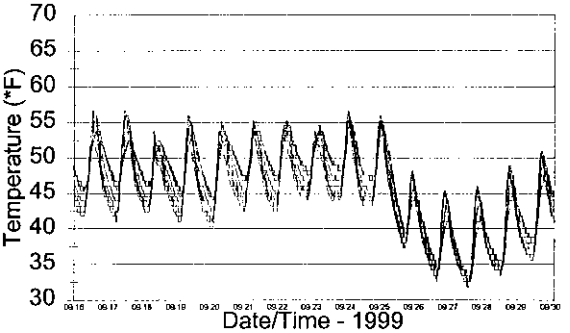
Dave Creek

All Stations



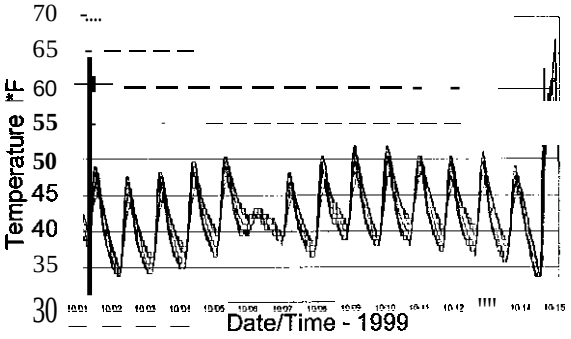
Dave Creek

All Stations



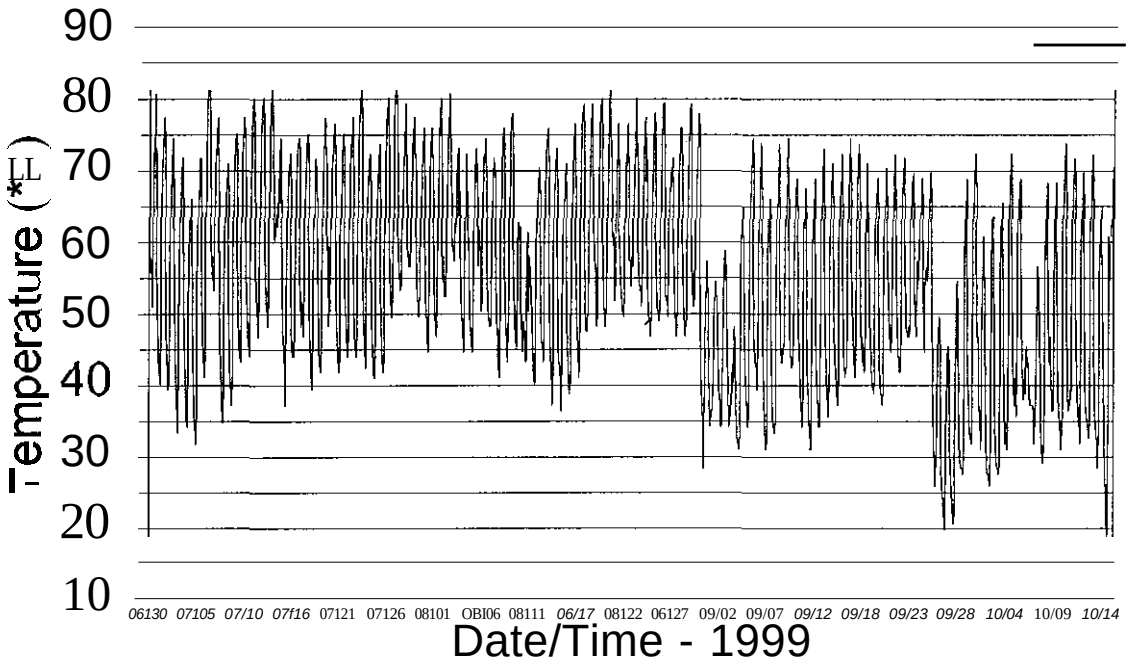
Dave Creek

All Stations

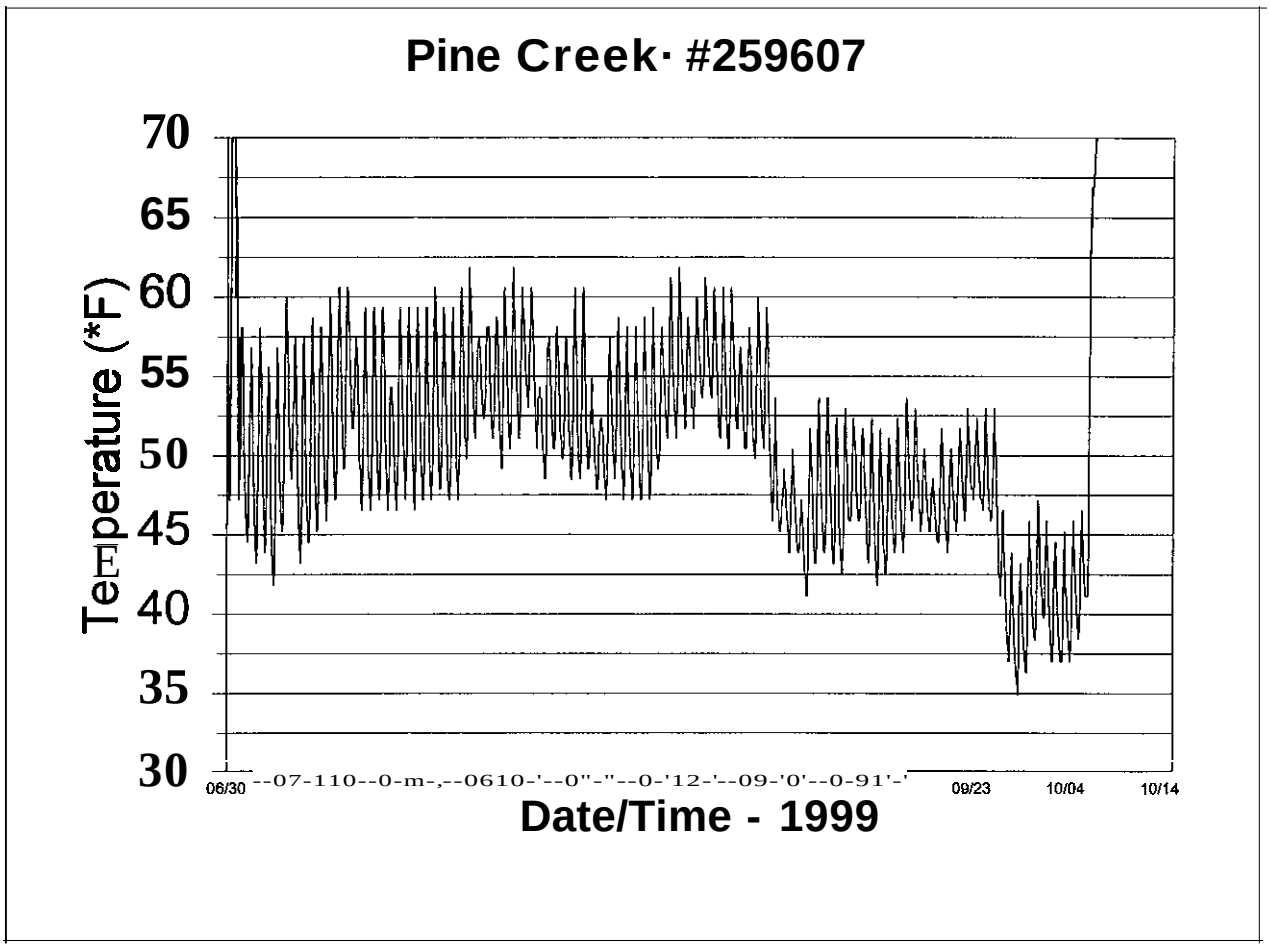


Dave Creek

Air Station - #190343



APPENDIXE


Pine Creek· #259607
70
65
60
55
50
45
40
35
30
Temperature (*F)
06/30
09/23
10/04
10/14
Date/Time - 1999