RECLAMATION

Managing Water in the West

Technical Memorandum No. 86-682900-04-07

Bear Creek Thermal Refugia Survey, 2007

U.S. Department of the Interior
Bureau of Reclamation

December 2007

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

U.S. Department of the Interior
Bureau of Reclamation

December 2007

BUREAU OF RECLAMATION
Technical Service Center, Denver, Colorado
Fisheries and Wildlife Resources Group, 86-68290

Technical Memorandum No. 86-68290-04 -07

Bear Creek Thermal Refugia Survey, 2007

U.S. Department of the Interior
Bureau of Reclamation
Lower Columbia Area Office
Portland, Oregon

Ron Sutton 10-17-07

Prepared: Ron Sutton
Fishery Biologist, Fisheries and Wildlife Resources Group 86-68290

Ronald Costello 9/26/07

Peer Review: Ron Costello
Fishery Biologist, Pacific Northwest Regional Office PN-1055

Bryan W 10/12/07

Peer Review: Bryan Horsburgh
Biologist, Pacific Northwest Regional Office PN-6520

Rich Piaskowski 9/25/07

Peer Review: Rich Piaskowski
Fishery Biologist, GeoEngineers

Wayne S Wright 09-25-07

Peer Review: Wayne Wright
Fishery Biologist, GeoEngineers

Steve Hiebert 86-68290 10-17-2007

Technical and Managerial Approval: Steve Hiebert
Manager, Fisheries and Wildlife Resources Group 86-68290

Date

Technical Memorandum No. 86-682900-04-07

Bear Creek Thermal Refugia Survey, 2007

Prepared by:

Ron Sutton
Bureau of Reclamation, Box 25007, 86-68920, Denver, CO 80225
rsutton@do.usbr.gov, (303) 445-2495

U.S. Department of the Interior
Bureau of Reclamation

December 2007

Table of Contents

List of Tables

List of Figures

1.0 Introduction

Summer thermal refugia are typically identified as areas of cool water created by inflowing tributaries, springs, seeps or through upwelling hyporheic flow (Hatch et al. 2006), and groundwater (Gilbert et al. 1997) in an otherwise thermally warm-wetted stream channel. In general, thermal refugia are thought to be important because they create thermally tolerable zones that allow fish to access and utilize main-stem habitats that otherwise would be unavailable to them due to high water temperatures (Kaya et al. 1977; Bilby 1984; Ozaki 1988; Nielsen et al. 1994; Biro 1998; Torgersen et al. 1999; Ebersole et al. 2001, 2003).

Summer temperatures have long been recognized as a critical limiting factor for fishes in the Rogue Basin. Perhaps one of the earliest documented observations of this is from Fred C. Ziesenhenne, Biologist, U.S. Forest Service (USFS). While conducting interior Rogue Basin stream surveys in 1935 (Ziesenhenne 1935, as cited in Rivers 1963), he noted:

> "…water temperatures are generally the most important single factor in limiting the species and distribution of fishes. The water temperature of the various streams during the summer ranges from 52^{o} to 60^{o} F (11-16 ^{o}C). Smaller creeks, well shaded during the day, ranged from 48^{o} to 56^{o} F (9-13 ^{o}C), while the rocky and exposed creeks had abnormal reading during the heat of the day…on one occasion on August 11, the water reading at the mouth [Illinois River] was 78^{o} F (26 ^{o}C) at 1:35 pm….."

Bear Creek valley is the warmest and driest interior valley in western Oregon (Horton 2001). Rivers (1963) describes the following for Bear Creek valley and the surrounding area:

> "The Rogue from 700 to 2,500 feet (0.2-0.8 km) elevation from the mouth of Trail Creek down to Galice and the Bear Creek Valley to a point above Ashland is classified in the upper Sonoran zones. This zone is characterized by hot, dry summers and has the highest average annual temperature along with the lowest normal yearly precipitation of any section of the basin. Many grasses and brush typical to northern California and Eastern Oregon are found in this zone. The trees are mainly Oregon white oak, California black oak, canyon live oak, Pacific madrone, and Oregon ash. The shrubs are mainly Manzanita, bitterbrush, poison oak, narrow leafed buck brush, and hardtack. A few of the herbaceous plants are the lupines, California poppy, common St. John's wart, lotus, and western yarrow."

The warm climatic conditions of the Bear Creek valley, high air and water temperatures, and naturally low summer flows (Oregon Department of Water Resources (ODWR) 2007) are suspected to severely limit juvenile coho salmon (*Oncorhynchus kisutch*) survival and distribution, and may explain the consistently low coho smolt production and lack or very limited adult use observed (Rivers 1963; U.S. Fish and Wildlife Service (USFWS) ca 1955; Vogt 2004).

We are unaware of any spawner surveys for salmonids in Bear Creek prior to 1949. Spawning surveys by USFWS in 1949 to 1954 did not find coho using the Bear Creek watershed; however they were located extensively in other drainages within the Upper Rogue Basin (USFWS ca 1954).

To predict historical distribution of coho salmon in the Southern Oregon and Northern California Coast (SONCC) Evolutionarily Significant Unit, Williams et al. (2006) defined the historical distribution of coho as any stream reach with a mean gradient of less than or equal to 7%. They excluded any reaches upstream of a reach with 7% gradient from the range of distribution. They also excluded habitat above natural barriers identified by the California Coastal Conservancy's Fish Passage Assessment Database (The Coastal Conservancy 2004). Williams et al. (2006) assigned a 21.5°C (70.7°F) temperature mask within the SONC for the purposes of predicting summer parr capacity. As a result, the lower 16.25 km of Bear Creek is predicted to be unavailable to juvenile coho in summer. The temperature mask basically identifies areas where coho are unlikely to exist in the summer due to excessively warm temperatures.

Intrinsic or natural hydrology reflects the relationship between climate and landscape, which in Bear Creek includes a broad open valley of grass lands and scattered trees reflective of the soils, and the limiting hot summer temperatures and dry conditions (Horton 2001). Although Native American Indians commonly set fires in Rogue Valley during summer, these fires were believed to be low intensity and probably did little to impact riparian tree cover, and maintained a forest of older scattered trees (Horton 2001).

Comparatively, neighboring Little Butte Creek, a drainage covered extensively by coniferous forest, and having a snow pack driven hydrology (Little Butte Creek Watershed Council (LBCWC) 2003), consistently produces large numbers of coho salmon smolts and is considered one of the best coho and steelhead (*O. mykiss*) producing watersheds in the Rogue River National Forest (USFS 1999) and Rogue River Basin (Vogt 2001). Little Butte includes high elevation low gradient reaches, ideal habitat for rearing coho salmon which remain cool throughout the summer.

The Bureau of Reclamation (Reclamation) conducted a recent two-year study of fish use (electrofishing), water temperature (datalogging temperature devices) and stream flow along a reach of upper Bear Creek and selected tributaries during periods of elevated water temperatures and low flows (Broderick 2000). Sampling eight locations along mainstem Bear Creek and in eight different tributaries, only one juvenile coho was located during the two year study in the Bear Creek Watershed. Temperature data collected suggested thermal refugia exists for coho salmon in upper reaches of the watershed and selected tributaries, however no thermal refugia were identified in the lower half of the watershed.

In a study of fish and water temperature during the summers of 1990 and 1991 (Dambacher et al. 1992), the Oregon Department of Fish and Wildlife (ODFW) in a cooperative study with USFS and Rogue Valley Council of Governments, found the following:

- Temperatures in lower Bear Creek approaching 27°C (80°F);
- Temperatures in tributaries exceeding 27°C (80°F);
- Bear Creek temperatures strongly controlled by solar input;
- Maximum Bear Creek temperatures occurred in late July;
- Salmonids existed in Bear Creek only down to an area half-way between Phoenix and Medford; and
- No steelhead were found in areas where temperatures exceeded 24°C (75°F).

More recently, ODFW sampled juvenile and smolt salmonids, including coho salmon, in the mainstem of Bear Creek, located in southern Oregon near Ashland, and its tributaries during the winter and spring months (Jay Doino and Chuck Fustish, ODFW, personal communication). However, it does not appear that the ODFW has recently surveyed the aforementioned streams (mainstem Bear Creek and tributaries) for salmonids during the summer months when high water temperatures may restrict coho juvenile rearing (0 and 0+ age classes) in the Bear Creek drainage and associated thermal refugia.

To investigate thermal refugia availability in summer and expanding upon the previous effort of Broderick (2000), Dambacher et al. (1992) and others, a reconnaissance was conducted by Reclamation and GeoEngineers (technical representatives of Rogue Basin Water Users Council) in accessible areas of Bear Creek and its tributaries in 2007. The purpose of this effort was to locate thermal refugia for salmonids in the Bear Creek system, particularly coho salmon, during the hot summer period. This study was coordinated with another temperature monitoring study conducted by Reclamation's Pacific Northwest Regional Office.

2.0 Methods

A three-person crew, consisting of two fisheries biologists from Reclamation (Denver Technical Services Center and Portland Area Office) and another from GeoEngineers, Inc. (Portland, Oregon), conducted the reconnaissance. Stream reaches within a list of known tributaries were prioritized in order to make the most efficient use of available time (2.5 days). The work was conducted during the timeframe of August 21-23, 2007.

On August 21th, the thermal refugia reconnaissance consisted of wading the Bear Creek channel from the Oak Street Diversion in Ashland downstream to Lynn Newberry Park in Phoenix (approximately 6 km) in search of thermal refugia. The Oak Street Diversion was selected as the upper boundary for this reach of the reconnaissance because water diversion at this site reduces the downstream water volume in Bear Creek and therefore was hypothesized to influence downstream daily water temperatures. Reaches upstream from this point are generally cooler and influenced by cooler water from Emigrant Reservoir irrigation water releases and tributary inflows originating from mountains in the southwest portion of Bear Creek Watershed (which includes Mt. Ashland). Bear Creek discharge was determined from Reclamation's BASO Hydromet station located on Bear Creek downstream of the Oak Street Diversion facilities and Ashland Creek confluence.

On August 22st and 23nd, the reconnaissance was continued by driving to and walking selective reaches of mainstem Bear Creek and its major tributaries between Emigrant Dam and the mouth of Bear Creek. The following information was obtained at each potential thermal refuge observed during the reconnaissance:

1. Photographs of important habitat features and landmarks near each thermal refugia;
2. Coordinates using a portable Global Positioning System (GPS) unit (NAD83);
3. Instantaneous temperatures taken using an electronic temperature sensor in the cool water source (e.g. tributary, spring, etc.), and in the mainstem Bear Creek above and below the cool water source;
4. An aqua scope viewing device was used to observe and identify any salmonids within potential refugia; and
5. General microhabitat conditions (i.e., depth, velocity, cover, temperature) where salmonids were observed were recorded.

During the survey, remote electronic Onset Tidbit temperature datalogging sensors were deployed to record water temperatures every 30 minutes in the following locations that were not being monitored in the aforementioned Pacific Northwest Region study:

1 – Neil Creek near its mouth
2 – Wagner Creek below West Canal Diversion
3 – Wagner Creek near its mouth
4 – Bear Creek just upstream from Wagner Creek confluence
5 – Larson Creek near its mouth
6 – Bear Creek just upstream from Larson Creek confluence

These temperature sensors recorded water temperatures every 30 minutes until they were retrieved on October 10, 2007.

3.0 Results and Discussion

Air temperatures between survey dates were similar, with daily maximum temperatures reaching 29°C (84°F), 30°C (86°F), and 33°C (91°F) for August 21, 22, and 23, respectively (http://weather.twincities.com/history/airport/KMFR/2007/8/23/DailyHistory.html). Table 1 summarizes water discharge and temperatures recorded at the BASO Hydromet station on Bear Creek during the survey period. Discharges ranged from 32.5 to 37.7 cfs and maximum daily temperatures ranged from 22.1°C (71.8°F) to 22.4°C (72.3°F) at this Hydromet location during the three-day survey. For comparison, the hottest day of the summer occurred on August 31, in which average maximum water temperatures was 23.1°C (73.6°F) at BASO. These temperatures recorded during the survey exceeded the Oregon Department of Environmental Quality (ODEQ) water temperature standard of 18.0°C (64.4°F) for juvenile salmon rearing, based on seven-day average maximum temperature (ODEQ 2004). Sutton et al. (2007) observed most juvenile salmonids moving into a Klamath River thermal refuge when mainstem temperatures exceeded 22-23°C (72-73°F). Bell (1991) suggests an upper temperature limit of 25.6°C (78.1°F) for coho fry/juvenile rearing.

Table 1 Discharge and temperature measurements in Bear Creek below the Oak Street Diversion at Reclamation's Hydromet Station BASO, 2007 (provisional data subject to change).

Date	Avg Daily Discharge (cfs)	Minimum water temperature (°C (°F))	Maximum water temperature (°C (°F))	Average water temperature (°C (°F))
August 21	32.5	19.3 (66.7)	22.4 (72.3)	20.7 (69.3)
August 22	36.8	18.0 (64.4)	22.1 (71.8)	20.1 (68.2)
August 23	37.7	17.3 (63.1)	22.3 (72.1)	19.8 (67.6)

Table 2 provides a summary of survey data at various locations within the Bear Creek drainage. Potential thermal refugia sites are bolded and highlighted in blue, based on temperatures that are cooler than those of the mainstem Bear Creek. Since we primarily focused on areas that were accessible, it should be noted that Table 2 most likely does not capture all areas of thermal refugia in the stream.

Examination of this table shows that temperatures were highest in the late afternoon, reflecting the strong influence of warm meteorological conditions that were experienced during the survey period. Despite apparent abundant shading from riparian vegetation along the Bear Creek corridor, the warmest temperatures were observed in mainstem Bear Creek during the survey. The warmest instantaneous water temperature measured was 22.8°C (73.0°F) in mainstem Bear Creek in late afternoon on August 21st in the town of Phoenix. Coolest temperatures were observed in upper reaches of certain tributaries. The coolest temperature measured was 14.1°C (57.4°F) in Neil Creek on the afternoon of August 22nd near the Hwy I-5 crossing.

A limited reconnaissance survey was conducted to observe salmonids in thermal refugia. Age 0+ and 1+ steelhead were observed at several locations in mainstem Bear Creek and tributaries (Table 2). No coho salmon were observed during the reconnaissance, although their presence cannot be ruled out given the level of effort and methods employed.

Thirteen potential summer thermal refugia were identified along Bear Creek mainstem, including 10 tributaries and 3 seeps/springs. Most potential thermal refugia were located in the upper half of Bear Creek watershed (Figures 1 and 2), with most being tributary inflows originating in the southwest portion of Bear Creek watershed. This portion of the watershed includes higher elevation, snowpack driven hydrology as compared to the east side of Bear Creek Watershed. Identified thermal refugia also included upper Bear Creek and Emigrant Creek which are supplemented with cooler discharges from storage in Emigrant Reservoir. Very few seeps were located in the reach intensively surveyed between Oak Street Diversion and Phoenix Diversion.

Few tributaries on the eastern portion of Bear Creek Watershed were identified as having thermal refugia, with most having little to no flow during the time of the survey. Larson Creek was one exception, which contained flows at the time of survey largely due to irrigation and residential irrigation runoff and returns (Jim Pendleton, Talent Irrigation District, personal communication).

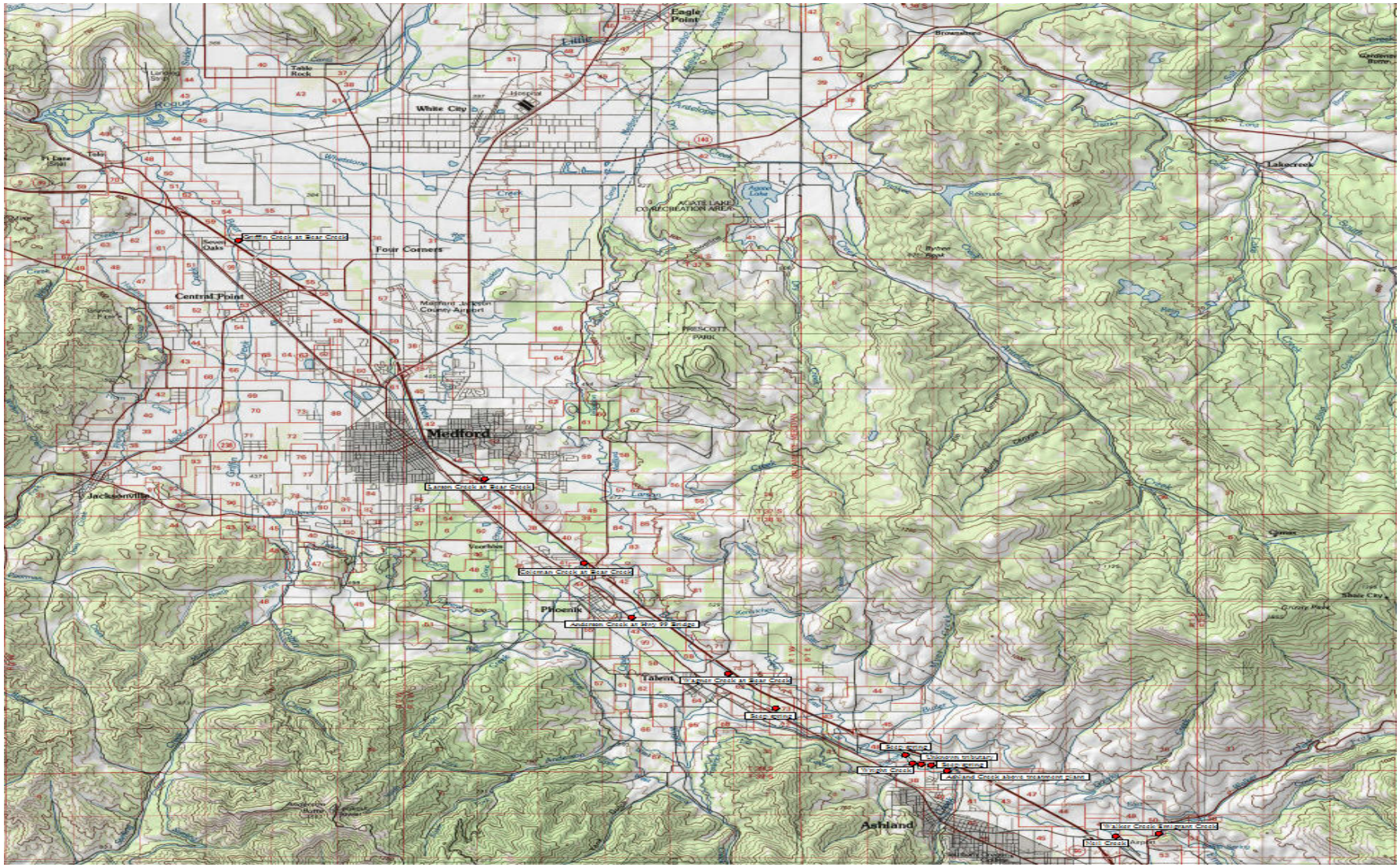

Figure 1 Overview of Bear Creek with locations of observed thermal refugia.

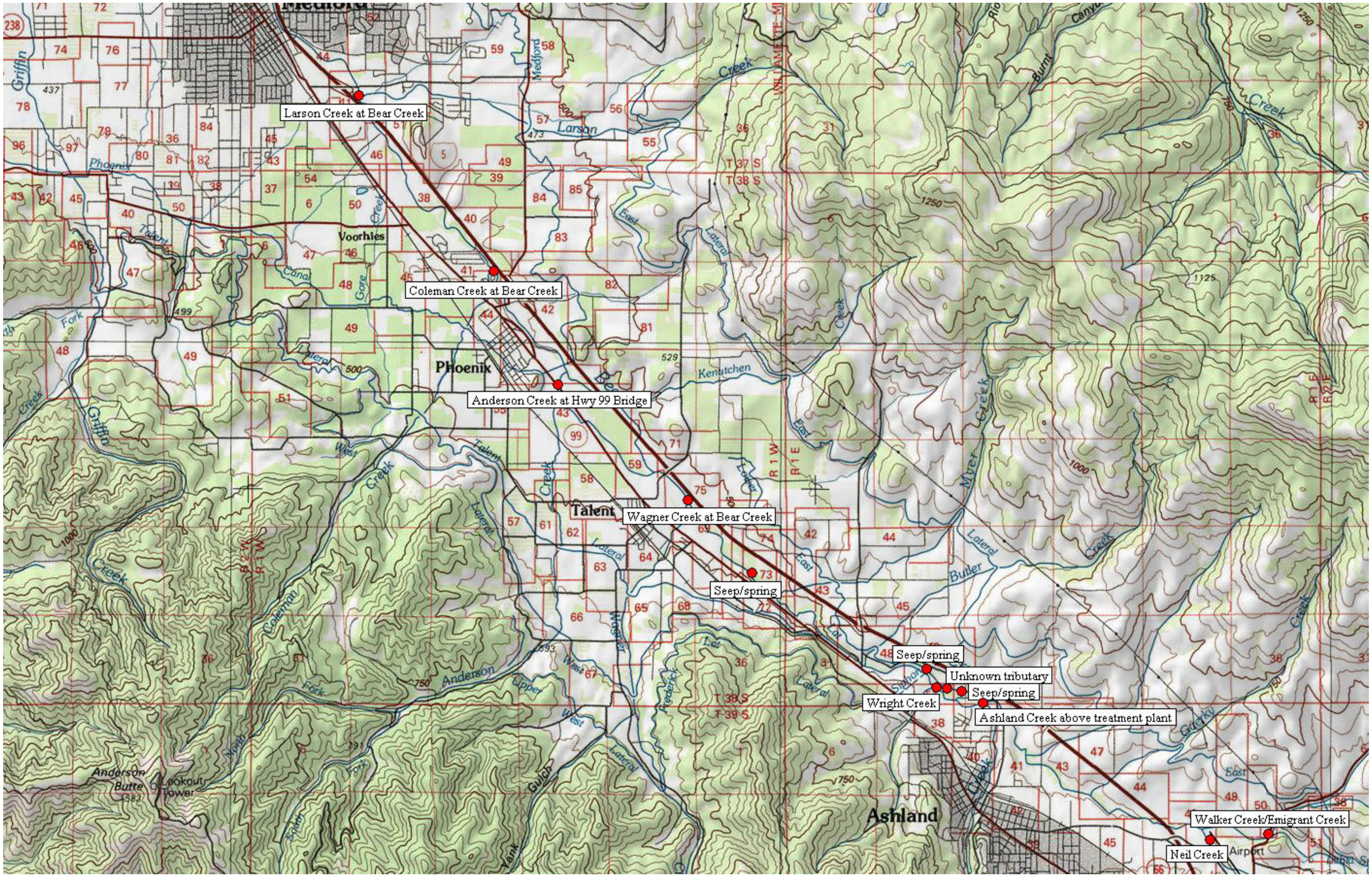

Figure 2 Locations of most potential summer thermal refugia for rearing salmonids in Bear Creek drainage.

Table 2 Thermal refugia reconnaissance survey data from Bear Creek drainage, 2007. Potential refuge (those sites having cooler water than the surrounding mainstem Bear Creek have text that are bolded and blue).

Date	Time	Location	Coordinates	Water Temperature (ºC (ºF))	Temperature Difference Between Refuge and Ambient Stream (ºC)	Fish Observed	Notes
8/21/2007	10:48 AM	Bear Creek at Oak Street Diversion	N 42º 12.950' W 122º 42.708'	Tailrace, 19.7 (67.5)			
8/21/2007	11:14 AM	Wasteway pipe return about 50 yds downstream from diversion		19.8 (67.6)			
8/21/2007	11:40 AM	Concrete stream crossing	N 42º 12.961' W 122º 42.945'	20 (68)			
8/21/2007	11:50 AM	Spawning gravel against right bank about 100 yds upstream from footbridge	N 42º 12.942' W 122º 43.101'				
8/21/2007	**11:55 AM**	**Coldwater seep about 75 yds upstream from footbridge**	**N 42º 12.935' W 122º 43.122'**	**20 (68)**		**Dace, salmonids (50-60 mm)**	**Seep potential thermal refuge**
8/21/2007	12:09 PM	Ashland Cr/Bear Cr confluence	N 42º 12.914' W 122º 43.128'	Ashland Cr, 22.0 (71.6); Bear Cr, 20.1 (68.2)			
8/21/2007	12:23 PM	Hydromet station	N 42º 12.924' W 122º 43.263'	20.8 (69.4)			Bear Creek flow about 32 cfs
8/21/2007	**12:41 PM**	**Unknown tributary-right bank**	**N 42º 13.017' W 122º 43.404'**	**Tributary, 20.1 (68.2); Bear Creek, 20.8 (69.4)**	**0.7**	**About 25 0+ steelhead**	**Tributary potential thermal refuge**
8/21/2007	**12:47 PM**	**Wright Creek**	**N 42º 13.070' W 122º 43.476'**	**Wright Cr, 17.6 (63.7); Bear Cr, 20.8 (69.4)**	**3.2**		**Wright Creek potential thermal refuge - flow about 0.5 cfs**
8/21/2007	**1:05 PM**	**Seep/Spring**	**N 42º 13.207' W 122º 43.608'**	**Seep, 18 (64.4); Bear Cr, 20.8 (69.4)**	**2.8**		**Seep potential thermal refuge - flow about 2 gpm; old pipeline crossing**

Date	Time	Location	Coordinates	Water Temperature (ºC (ºF))	Temperature Difference Between Refuge and Ambient Stream (ºC)	Fish Observed	Notes
8/21/2007	1:17 PM	Bear Creek	N 42º 13.258' W 122º 43.750'	21.1 (70.0)			
8/21/2007	1:45 PM	Bear Creek	N 42º 13.247' W 122º 44.280'	21.5 (70.7)			
8/21/2007	1:55 PM	Butler Creek (?) about 50 yds upstream from Valley Bridge	N 42º 13.274' W 122º 44.360'	21.6 (70.9)			
8/21/2007	3:32 PM	Bear Creek at PHABSIM study site	N 42º 13.658' W 122º 45.031'	22.5 (72.5)			
8/21/2007	4:10 PM	Bear Creek	N 42º 13.801' W 122º 45.268'	22.8 (73.0)			
8/21/2007	**-**	**Seep/Spring**	**N 42º 14.177' W 122º 45.905'**	**Seep, 18.4 (65.1); Bear Cr, 22.7 (72.9)**	**4.3**		**Seep potential thermal refuge - flow about 5 gpm**
8/21/2007	5:05 PM	Bear Creek	N 42º 14.546' W 122º 46.339'	22.8 (73.0)			
8/21/2007	5:35 PM	Bear Creek	N 42º 14.645' W 122º 46.521'	22.8 (73.0)			
8/21/2007	**6:05 PM**	**Wagner Cr/Bear Cr confluence**	**N 42º 14.867' W 122º 46.750'**	**Wagner Cr, 18.8 (65.8); Bear Cr, 22.5 (72.5)**	**2.7**		**Wagner Creek potential thermal refuge - flow about 1 cfs**
8/22/2007	**9:43 AM**	**Neil Creek near mouth**	**N 42º 11.537' W 122º 39.855'**	**16.3 (61.3)**		**0+ steelhead**	**Neil Creek potential thermal refuge - flow about 2-3 cfs**
8/22/2007	**9:55 AM**	**Emigrant Cr/Walker Cr confluence**	**N 42º 11.588' W 122º 39.084'**	**Walker Cr, 15.6 (60.1); Emigrant Cr, 19.2 (66.6)**			**Walker Creek and Emigrant Creek potential thermal refugia**
8/22/2007	10:45 AM	Bear Creek at Phoenix Diversion	N 42º 15.171' W 122º 47.127'	Tailrace, 17.9 (64.2); Forebay, 17.9 (64.2)			

Date	Time	Location	Coordinates	Water Temperature (ºC (ºF))	Temperature Difference Between Refuge and Ambient Stream (ºC)	Fish Observed	Notes
8/22/2007	**12:55 PM**	**Ashland Creek at Lithia Park**	**N 42º 11.880' W 122º 42.950'**	**19.1 (66.4)**			
8/22/2007	**1:30 PM**	**Ashland Creek at Wastewater Treatment Plant**	**N 42º 12.877' W 122º 42.837'**	**Ashland Cr above plant, 16.6 (61.9); below plant, 21.6 (70.9)**			**Wastewater release about 2 mgd; 0.5 NTUs**
8/22/2007	1:43 PM	Ashland Creek at stream gage	N 42º 12.880' W 122º 42.993'	21.8 (71.2)			
8/22/2007	**2:27 PM**	**Neil Creek at Hwy 66 Bridge**	**N 42º 10.205' W 122º 38.471'**	**18.9 (66.0)**			
8/22/2007	**2:45 PM**	**Neil Creek at Hwy I-5**	**N 42º 08.264' W 122º 38.125'**	**14.1 (57.4)**			**Ditch 1852**
8/22/2007	**3:30 PM**	**Walker Creek upstream of East Canal**	**N 42º 11.998' W 122º 38.727'**	**18.4 (65.1)**			
8/22/2007	**5:05 PM**	**Anderson Creek at Hwy 99 Bridge**	**N 42º 16.065' W 122º 48.533'**	**20.8 (69.4)**			**Anderson Creek - potential thermal refuge - flow about 2-3 cfs**
8/22/2007	**5:20 PM**	**Coleman Cr/Bear Cr confluence**	**N 42º 17.103' W 122º 49.263'**	**Coleman Cr, 20.9 (69.6); Bear Cr above Coleman Cr, 22.3 (72.1)**	**1.4**		**Coleman Creek - potential thermal refuge - flow about 1.5 cfs**
8/22/2007	**5:50 PM**	**Larson Cr/Bear Cr confluence**	**N 42º 18.853' W 122º 51.077'**	**Larson Cr, 21.6 (70.9); Bear Cr above Larson Cr, 22.4 (72.3)**	**0.8**	**Too turbid to scope**	**Larson Creek - potential thermal refuge - flow about 4 cfs**
8/23/2007	8:35 AM	Bear Creek near Fairgrounds	N 42º 23.471' W 122º 55.117'	17.2 (63.0)			
8/23/2007	**8:58 AM**	**Griffith Cr/Bear Cr confluence**	**N 42º 23.481' W 122º 55.201'**	**Griffith Cr, 16.7 (62.1); Bear Cr, 17.6 (63.7)**	**0.9**		**Griffith Creek flow about 2 cfs**
8/23/2007	9:20 AM	Jackson Cr/Bear Cr confluence	N 42º 23.743' W 122º 55.506'	Jackson Cr, 17.8 (64.0); Bear Cr, 17.4 (63.3)			Jackson Creek flow about 8-10 cfs
8/23/2007	9:37 AM	Seep/Spring - right bank Bear Cr	N 42º 23.769' W 122º 55.527'	18 (64.4)			Seep flow about 250 gpm

Date	Time	Location	Coordinates	Water Temperature (ºC (ºF))	Temperature Difference Between Refuge and Ambient Stream (ºC)	Fish Observed	Notes
8/23/2007	10:05 AM	Willow Creek at Hwy I-5 box culvert	N 42º 24.402' W 122º 56.492'	18.2 (64.8)			Willow Creek flow about 8-10 cfs; culvert passage restriction
8/23/2007	10:35 AM	Bear Creek near mouth	N 42º 25.806' W 122º 57.957'	18.7 (65.7)			
8/23/2007	**12:30 PM**	**Wagner Cr/Bear Cr confluence**	**N 42º 14.867' W 122º 46.750'**	**Wagner Cr, 16.2 (61.2); Bear Cr, 18.8 (65.8)**	**2.6**		**Deployed temperature sensors:Wagner Cr - #1179551; Bear Cr - #1179560**
8/23/2007	**1:02 PM**	**Wagner Cr below West Canal**	**N 42º 12.887' W 122º 47.409'**	**Above diversion, 15.3 (59.5); below diversion, 15.7 (60.3)**		**Many 0+ and 1+ steelhead below diversion**	**Deployed temperature sensor below diversion - #1179553**
8/23/2007	**3:00 PM**	**Neil Creek near mouth**	**N 42º 11.537' W 122º 39.855'**	**19.9 (67.8)**		**0+ steelhead**	**Deployed temperature sensor - #1179565**
8/23/2007	3:20 PM	Bear Creek at Mountain Nature Park	N 42º 12.251' W 122º 41.828'	21.7 (71.1)		Too turbid to scope	
8/23/2007	5:30 PM	Larson Cr/Bear Cr confluence	N 42º 18.853' W 122º 51.077'	Larson Cr, 21.5 (70.7); Bear Cr above Larson Cr, 22.5 (72.5)		Too turbid to scope	Larson Creek flow about 2 cfs; Deployed temperature sensors:Larson Cr - #1179550; Bear Cr - #1179549

The sensor at Neil Creek was located out of the water when it was retrieved, so its data are likely compromised. Also, the sensor on lower Wagner Creek near its mouth malfunctioned. Thirty-minute plots of temperatures from five of the sensors are illustrated in Figures 3-5. These plots show differences between tributary and mainstem Bear Creek temperatures. Several noticeable results are apparent in these figures. One is that Larson Creek temperatures were similar to Bear Creek temperatures, although generally Larson Creek had lower maximum daily temperatures than Bear Creek (Figure 3). The maximum daily temperatures during the monitoring period were 23.6°C (74.5°F) and 23.9°C (75.0°F) in Larson Creek and Bear Creek, respectively, which occurred on August 30, 2007. These high temperatures suggest that Larson Creek provides a marginal thermal refuge at its mouth. Another result is that upper Wagner Creek was consistently cooler than mainstem Bear Creek (Figure 4). The maximum daily temperatures during the monitoring period were 17.9°C (64.2°F) and 23.0°C (73.4°F) in upper Wagner Creek and Bear Creek, respectively, which occurred on August 31, 2007. This demonstrates the importance of upper tributary reaches as summer thermal refugia.

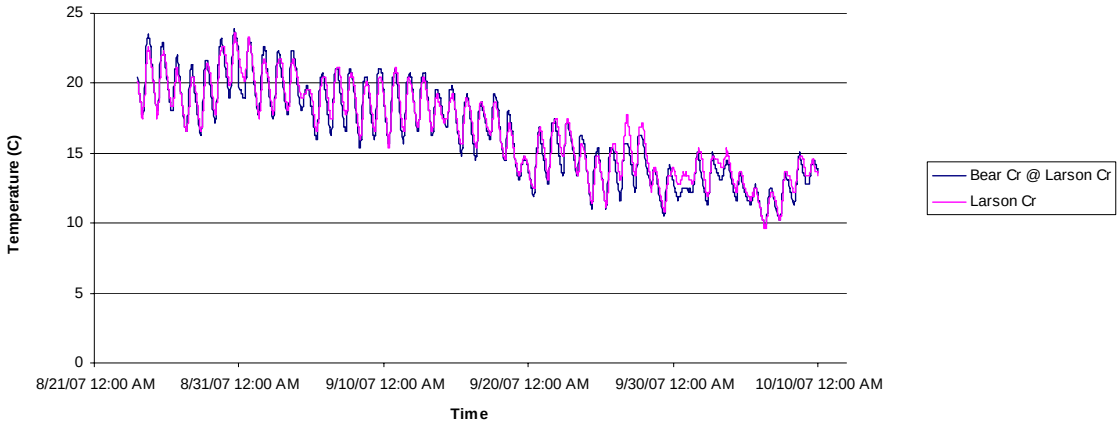

Figure 3 Temperature data from lower Larson Creek and Bear Creek at Larson Creek confluence.

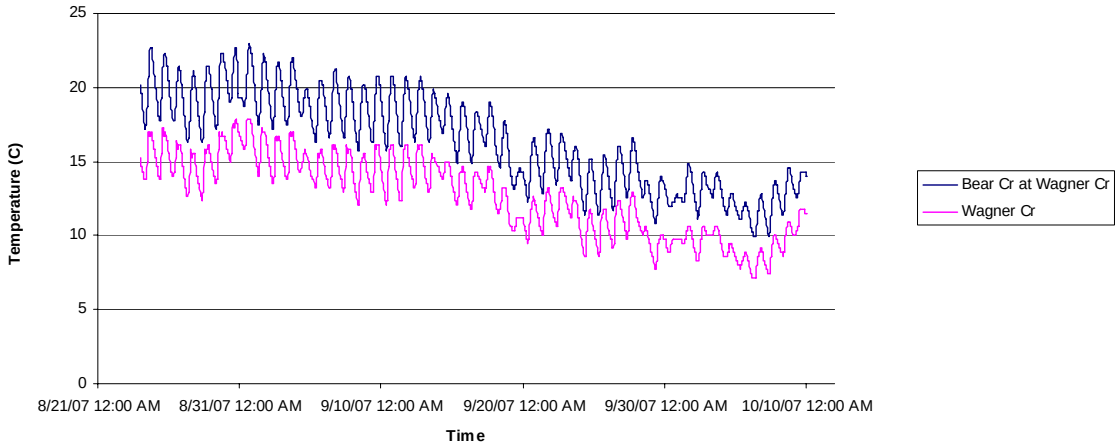

Figure 4 Temperature data from upper Wagner Creek and Bear Creek at Wagner Creek confluence.

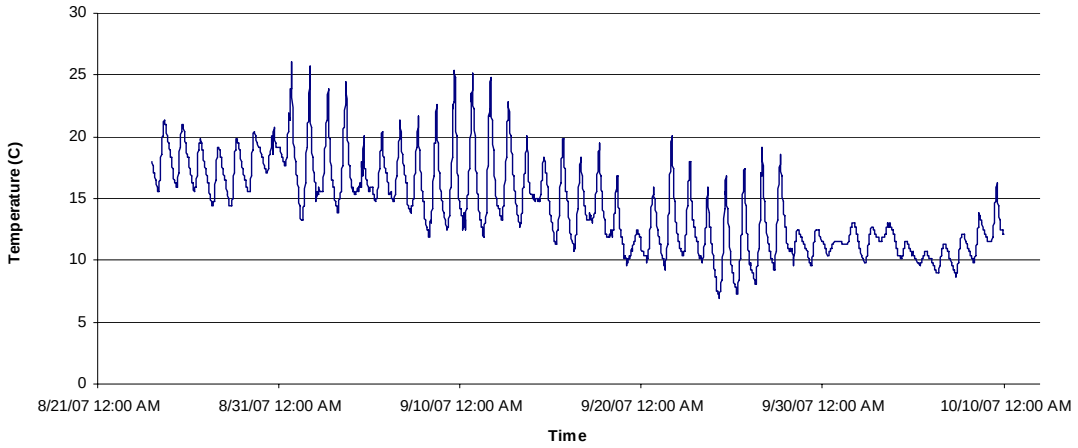

Figure 5 Temperature data from lower Neil Creek (note: sensor retrieved exposed to air).

Figures 6 through 11 are photographs taken at various locations during the survey.

Figure 6 Tailrace downstream from Oak Street Diversion on Bear Creek August 21, 2007.

Figure 7 Observing fish using an aquascope and measuring water temperature at a cool water seep in Bear Creek, August 21, 2007.

Figure 8 Unnamed tributary confluence with Bear Creek that contained about 25 0+ steelhead in Bear Creek, August 21, 2007.

Figure 9 Lower end of Larson Creek, a potential coho winter rearing area, August 22, 2007.

Figure 10 Bear Creek/Larson Creek confluence, August 22, 2007.

Figure 11 Observing steelhead downstream from West Canal Diversion on Wagner Creek, August 23, 2007.

Results from this investigation, and based on our review of previous work completed on this subject, suggest the critical importance of the limiting effects of warm summer water temperature as it relates to coho salmon production and use in Bear Creek Watershed. Water temperatures at all measured inflows to Bear Creek were below or very near water temperatures measured in mainstem Bear Creek. Certain tributaries had temperatures cooler than mainstem Bear Creek, providing potential thermal refugia to coho and other fishes when Bear Creek reaches critically warm temperatures in summer. Broderick (2000) found relatively high numbers of rainbow trout (nonmigratory) in Griffin Creek (1998), Larson Creek (1997), Coleman Creek (1997), and Wagner Creek (both 1997 and 1998), indicating rainbows can survive in these tributaries during adverse temperature conditions in summer. Dambacher et al. (1992) did not find juvenile coho salmon during summer electrofishing surveys in Bear Creek, but they found many 1+ age steelhead above Medford. They concluded that high water temperature was probably the single most important factor limiting the production of salmonids in the Bear Creek system (Dambacher et al. 1992).

4.0 Recommendations

Based on the results of this reconnaissance survey, the following recommendations are suggested:

1 - A comprehensive study is needed to understand how water temperatures relate to discharge within streams in Bear Creek valley relative to Rogue River Basin Project operations;

2 - Continued summer temperature monitoring of potential thermal refugia through the summer period to characterize temporal and spatial patterns relative to natural and Reclamation project supplemented flows;
3 - Monitor coho and steelhead use of potential thermal refugia using aquascopes and snorkeling during late July and early August (typically the hottest period of summer);
4 - Work with ODFW, Irrigation Districts, and Watershed Council to coordinate and develop a summer sampling plan using minnow traps, fyke nets, electrofishing and/or other methods to determine the presence, distribution and relative abundance of juvenile coho salmon during the summer in Bear Creek and Little Butte Creek drainages;
5 - Initiate summer flow monitoring of cool water tributaries using inexpensive stage recorders;
6 - Initiate microhabitat measurements (depth, velocity, substrate, cover, temperature) of salmonid locations within thermal refugia, with emphasis on coho salmon;
7 - Conduct an assessment of the contribution of riparian vegetation shading to solar loading in mainstem Bear Creek upstream from Larson Creek (RM 12 (RKM 19)).

5.0 Acknowledgements

I thank several people who contributed to the success of this study. Ron Costello, Ron Eggers, and Karen Blakney of Reclamation's Lower Columbia Area Office contributed to planning and funding. Ron Costello of Reclamation and Rich Piaskowski of GeoEngineers, Inc. assisted with the field reconnaissance and peer-review of an earlier draft. Bryan Horsburgh of Reclamation's Pacific Northwest Regional Office also peer-reviewed an earlier draft and provided additional temperature data in Bear Creek.

6.0 References

Bell, M.C. 1991. Fisheries handbook of engineering and biological criteria. M.C. Bell, 1991. Prepared for Fish Passage Development and Evaluation Program, Corps of Engineers, North Pacific Region, Portland, OR.

Bilby RE. 1984. Characteristics and frequency of cool-water areas in a westernWashington stream. Journal of Freshwater Ecology 2: 593–602.

Biro PA. 1998. Staying cool: behavioral thermoregulation during summer by young-of-year brook trout in a lake. Transactions of the American Fisheries Society 127: 212–222.

Broderick, S. 2000. Summer fish community surveys in Bear Creek, Little Butte Creek, and related tributaries, Jackson County, Oregon.

Coastal Conservancy (The). 2004. Inventory of barriers to fish passage in California's coastal watersheds. State Coastal Conservancy, Oakland, California.

Dambacher, J., R. Frick, and E. Dittmer. 1992. Bear Creek habitat and temperature study 1990-1991. A cooperative study. Oregon Department of Fish and Wildlife, Rogue River National Forest, and Rogue Valley Council of Governments. 31 pp.

Ebersole JL, Liss WJ, Frissell CA. 2001. Relationship between stream temperature, thermal refugia and rainbow trout Oncorhynchus mykiss abundance in arid-land streams in the northwestern United States. Ecology of Freshwater Fish 10: 1–10.

Ebersole JL, Liss WJ, Frissell CA. 2003. Thermal heterogeneity, stream channel morphology, and salmonid abundance in northeastern Oregon streams. Canadian Journal of Fisheries and Aquatic Science 60: 1266–1280.

Gilbert J, Mathieu J, Fournier F. 1997. The groundwater–surface water ecotone persective: the state of the art. In Groundwater/Surface Water Ecotones: Biological and Hydrological Interactions and Management Options, Gilbert J, Mathieu J, Fournier F (eds). Cambridge University Press: Cambridge; 3–8.

Hatch EC, Fisher AT, Revenaugh JS, Constantz J, Ruehl C. 2006. Quantifying surface water—ground water interactions using time-series analysis of streambed thermal records: method development. Water Resources Research 42(10): W10410.

Horton, R. 2001. Bear Creek Watershed Assessment, Phase II Bear Creek Tributary Assess, Part I Bear Creek Watershed. Prepared for Berar Creek Watershed Council.

Kaya CM, Kaeding LR, Burkhalter DE. 1977. Use of a cold-water refuge by rainbow and brown trout in a geothermally heated stream. Progressive Fish Culturist 39: 37–39.

LBCWC. 2003. Little Butte Creek Watershed Assessment. Little Butte Creek Watershed Council, August 2003. 128 pp.

Nielsen JL, Lisle TE, Ozaki V. 1994. Thermally stratified pools and their use by O. mykiss in northern California streams. Transactions of the American Fisheries Society 123: 613–626.

Oregon Department of Water Resources. Data on natural stream flow estimates on various streams in Oregon reviewed September 2007 at OWRD website: http://www.wrd.state.or.us

Oregon Department of Environmental Quality (ODEQ). 2004. Water quality standards: Beneficial Uses, Policies, and Criteria for Oregon. Oregon Administrative Rules, Chapter 340, Division 041.

Ozaki VL. 1988. Geomorphic and hydrologic conditions for cold pool formation on Redwood Creek, California. Redwood National Park Research and Development Technical Report 24; 57 pp.

Rivers, C.M. Rogue River fisheries. 1963. Volume 1: History and Developmetn of the rogue River Basin as Related to its Fishery Prior to 1941. Oregon State Game Commission.

Sutton, R.J., M.L. Deas, S.K. Tanaka, T.Soto, and R.A. Corum. 2007. Salmonid observations at a Klamath River themal refuge under various hydrological and meteorological conditions. *River Research and Applications*. Volume 23(7): 775-785. Published online in Wiley InterScience (www.interscience.wiley.com) DOI: 10.1002/rra.1026

Torgersen CE, Price DM, Li HW, McIntoch BA. 1999. Multiscale thermal refugia and stream habitat associations of Chinook salmon in northeastern Oregon. Ecological Applications 9: 301–319.

USFS. 1999. Coho Spawning Surveys, FY99 Report. Ashland Ranger District, Rogue River National Forest. Prepared by Gar Abbas, assistant fisheries biologist. Approved by Su Maiyo, zone fisheries biologist.

USFWS. No Date Included (ca 1955). Three Progress Reports 8-9, 19, 21-23 on Spawning Grounds and Populations in the Upper Rogue River 1949-1954.

Vogt, J. 2001. Upper Rogue smolt trapping project, 2001. Oregon Department of Fish and Wildlife, Rogue Fish District, Central Point, OR.

Williams, T. H., E. P. Bjorkstedt, W. D. Duffy, D. Hillemeier, G. Kautsky, T. E. Lisle, M. McCain, M. Rode, R. G. Scerlong, R. S. Schick, M. N. Goslin, A. Agrawal. 2006. Historical population structure of coho salmon in the Southern Oregon/Northern California coast evolutionarily significant unit. NOAA Technical Memorandum NMFS. NOAA-TM-NMFS-SWFSC-390. 71 pp.