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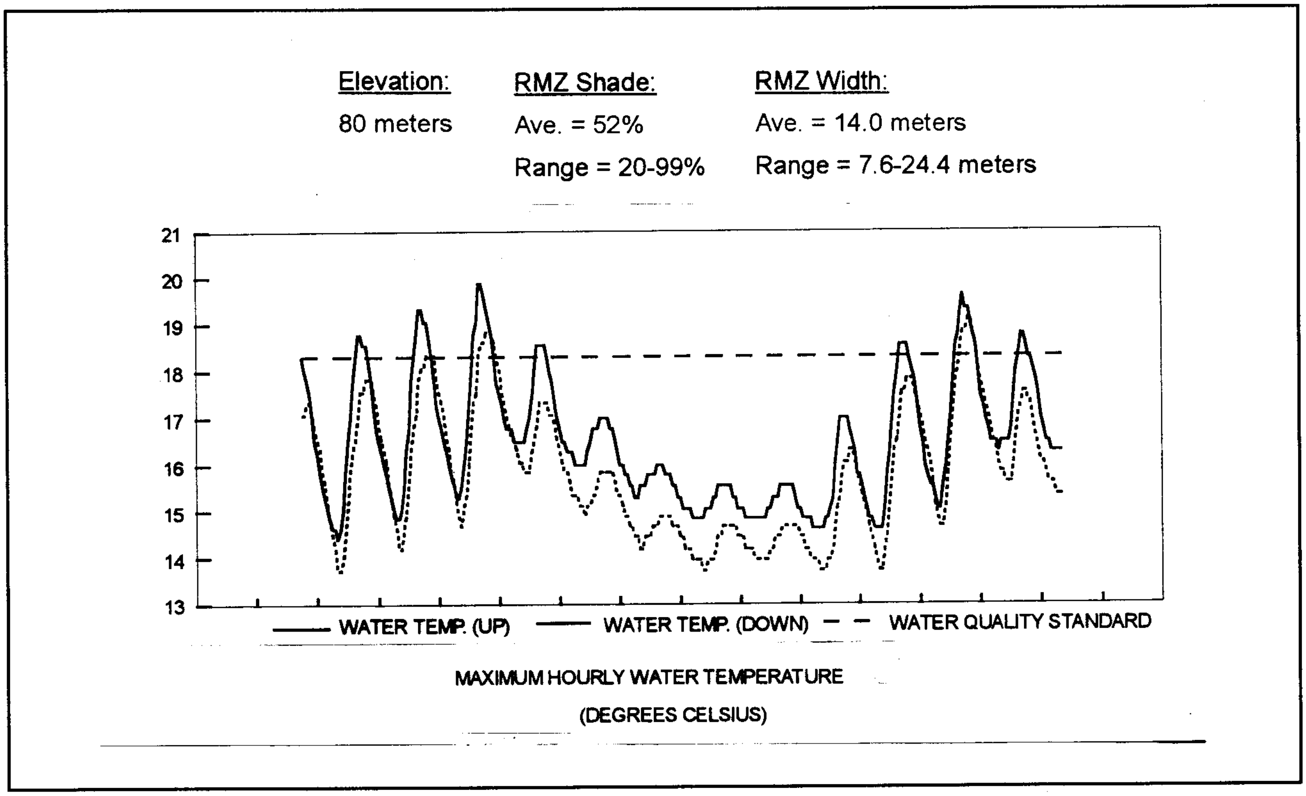
TFW Monitoring Program

METHOD MANUAL

for the

STREAM TEMPERATURE SURVEY



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Abstract

The TFW Monitoring Program method manual for the Stream Temperature (TEMP) Survey provides a standard method for assessing and monitoring the quantity and quality of stream temperature and thermal reach characteristics. The TEMP Survey provides a standard method for conducting annual maximum temperature monitoring studies to accomplish a variety of objectives, including assessment and monitoring of water temperature changes associated with land management activities, characterization and monitoring of stream reaches of special interest due to their importance for salmonid habitat or water quality, or characterization of temperature regimes throughout a watershed.

The monitoring approach involves collection of water temperature data at temperature stations, and optional characterization of channel and riparian conditions in thermal reaches immediately upstream of the temperature stations to identify factors affecting water temperature. Procedures cover the use of data logger and maximum/minimum temperature instruments for collecting water temperature data. Water temperature data are analyzed in the TFW Monitoring Program database and reports are generated that characterize the temperature regime for each temperature station on a daily, weekly, monthly and project basis. Cases where water quality standards have been exceeded are identified. Additional information can be collected on factors that affect the maximum water temperature regime, including air temperature, canopy closure (shade), reach elevation, stream width and depth, gradient, channel morphology and groundwater inflow.

The remainder of the introduction section describes the purpose of the TEMP Survey, reviews scientific background information, and describes the cooperator services provided by the TFW Monitoring Program. Following the introduction, sections are presented in order of survey application including: study design, pre-survey preparation, survey methods, post-survey documentation, data management, and references. An extensive appendix is also provided that includes: copy masters of field forms; examples of completed field forms; a standard field and vehicle gear checklist; data management examples; and a copy of the Washington State Water Quality Standards classification list.

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Copying of the TFW Manual

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1. Introduction

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1.1 Purpose

The Timber-Fish-Wildlife Monitoring Program (TFW-MP) provides standard methods for monitoring changes and trends in stream channel morphology and habitat characteristics. The TEMP Survey method has been approved by TFW's Cooperative Monitoring, Evaluation and Research Committee (CMER) and is accepted as a standard method for monitoring on forest lands in Washington state by tribal governments, state natural resource agencies, timber companies, environmental organizations, and others. The purpose of the TEMP Survey is to:

1. Document the temperature regime of stream reaches and determine if water quality standards for maximum stream temperatures are being exceeded.
2. Monitor changes in maximum temperature regime over time.
3. Optional: Document factors influencing stream temperature so the maximum stream temperature regime can be interpreted in the context of stream channel, riparian and watershed conditions.
4. Optional: Produce information that can be used to test and improve the TFW temperature screen and the empirical relations in the TFWTEMP stream temperature model.

1.2 Background

This section provides background information, including the effects of stream temperature on salmonid growth and survival, factors affecting stream temperature in forest streams, and management of stream temperature on forest lands.

1.2.1 Influence of Water Temperature on Salmonid Growth and Survival

Water temperature is a critical factor affecting the survival and growth of salmonid fish that reside in freshwater streams during the summer low flow period. Salmonids are sensitive to water temperature because they are cold-blooded and their internal body temperature must adjust to the temperature of the external environment. Salmonids have both lower and upper lethal temperature limits, which are specific for each species and may vary at different stages in their life history. Salmonids acclimate to seasonal temperature changes and fluctuations in temperature. They acclimatize more readily to increases than to decreases in temperature (Lantz, 1970).

The optimal temperature range for most salmonid species is approximately 12-14 degrees Celsius (53.6 - 57.2 degrees Fahrenheit). Increased stream temperature may have a beneficial effect on salmonids when it results in greater food production and increased growth, but only if it does not exceed the optimal temperature range (Beschta et al., 1987). Lethal levels for adult salmonids vary according to factors such as the acclimation temperature and the duration of the temperature increase, but are generally in the range of 23-29 degrees Celsius (73.4 - 84.2 degrees Fahrenheit)(Bjornn and Reiser, 1991). Bjornn and Reiser (1991) caution that, "although some salmonids can survive at relatively high temperatures, most are placed in life-threatening conditions when temperatures exceed 23-25 degrees Celsius, and they usually try to avoid such temperatures by moving to other areas." The egg and juvenile life history stages are the most sensitive to high temperatures (MacDonald et al., 1991). In some cases, the frequency and range of temperature changes may be more critical than the maximum temperature regime.

Within the lethal thermal limits, environmental factors operate in conjunction with temperature to reduce survival. Sub-lethal effects of above-optimal water temperatures often appear to be more critical than direct mortality. Examples of sub-lethal effects include:

- ♦ reduced survival of eggs and progeny when adults spawn in warm water (Lantz, 1970; Berman and Quinn, 1990).
- ♦ increased virulence of many of the diseases most significant in the Pacific Northwest including kidney disease, furunculosis, vibriosis and columnaris (Lantz, 1970).
- ♦ changes in distribution or migration patterns to avoid warm waters (Beschta et al., 1987; Berman and Quinn, 1990).
- ♦ increased metabolic activity that results in reduced growth rate when temperatures exceed the optimum level (Lantz, 1970; Beschta et al., 1987).
- ♦ change in timing of development and life history stages (Holtby, 1988).
- ♦ reduced ability to compete with other species (Beschta et al., 1987).

1.2.2 Factors Affecting Stream Temperature in Forest Streams

A number of environmental factors affect maximum stream temperature including solar energy inputs, transfer of heat with the surrounding air, and other factors.

Solar Energy Input

The principal source of heat for small streams is the solar radiation that directly strikes the surface of the stream (Brown, 1971). The amount of sunlight reaching the stream depends on the surface area of the stream and the shade provided by vegetation and topography. Wide, shallow streams receive more solar radiation relative to the volume of water than narrow, deep ones. For a given rate of solar radiation input, temperature change is directly proportional to surface area and inversely proportional to discharge (Sullivan et al., 1990).

In forested areas, overstory canopy vegetation is typically the primary shade factor for blocking the input of solar radiation to streams and other water bodies. Reduction in vegetative cover along streams due to harvest of riparian forests or natural disturbance increases incident solar radiation reaching the stream, resulting in higher maximum summer temperatures and larger diurnal fluctuations, especially in small streams

(Sullivan et al., 1990). On wide streams where riparian vegetation cannot shade the mid-channel area, shading of the stream margins may play an important role in moderating water temperature near the stream banks, providing refugia for fish and other aquatic life.

Transfer of Heat with the Surrounding Air

Summer air temperature is an important factor regulating maximum stream temperature due to the magnitude of heat exchange between the stream and the surrounding air. As the water moves downstream, it exchanges (gains/loses) heat with the air passing over the water surface. When the surrounding air is warmer (typically during the afternoon), the stream gains heat from the air (in addition to solar radiation). Conversely, when the surrounding air is cooler (during the night or on cold days), the stream loses its heat to the air and becomes cooler. Given equal amounts of solar radiation, streams in areas with cool air temperatures (especially nighttime temperatures) will remain cooler than streams in warmer areas. Consequently, streams in areas with warmer temperatures (low elevations, eastern Washington) require more shade to regulate solar energy input than those in cooler areas where greater heat loss occurs. Annual variation in climate (summer temperatures and cloud cover) or local climatic factors (summer fog belts) also affect the temperature regime of streams.

Other factors

Other factors also affect the maximum temperature regime of streams. Variation in discharge over time affects water depth and volume of water to heat. Input of water from other sources may locally influence summer stream temperatures. Ground water entering streams is typically cooler (often creating localized cool water refuges), while warmer water entering streams from shallow lakes and open wetlands may raise stream temperatures.

1.2.3 Management of Stream Temperature on Forest Lands

The maximum temperature allowable in a stream reach under the state water quality standards depends on the water quality classification of the reach. The Washington Department of Ecology sets water quality standards for maximum stream temperature. Most forest streams are classified as AA or A, with maximum allowable water temperatures of 16 and 18 degrees Celsius (60.8 and 64.4 degrees Fahrenheit), respectively. In addition, antidegradation clauses of the standards must be met. Streams classified as B shall not exceed 21 degrees Celsius (69.8 degrees Fahrenheit). The classification of streams is established by sections 120 and 130 of Chapter 173-201A WAC (Washington State Water Quality Standards). A copy of the water quality classification list is included in Appendix E. Note: Readers are advised that as of this manual version (June, 1999), Ecology is proposing a change to the state temperature standards. Contact the Ecology Water Quality Program at (360)407-6000 for the most up-to-date standards information.

The state forest practice rules for timber harvest require leave trees to provide shade in riparian management zones (RMZs) along fish-bearing waters and some of their tributaries. The shade requirements are estimated using empirically derived temperature screens based on the elevation of the site (Doughty et al., 1991; WFPB, 1996) or a predictive temperature model (Doughty et al., 1993). Rashin and Graber (1992) tested the effectiveness of riparian zone regulations and recommended periodic review and update of the temperature screen and model as new data became available. In 1993, review of additional data resulted in the development of a separate Eastern Washington temperature screen. Additional shade requirements that supersede the shade requirements of the forest practices rules may be adopted as a result of Watershed Analysis, Habitat Conservation Plans, or Landscape Plans.

1.3 Cooperator Services

The TFW Monitoring Program provides a comprehensive suite of services to support TFW cooperators collecting data consistent with program goals. Services include study design assistance, pre-season training through annual workshops and on-site visits, pre-season quality assurance reviews, data entry systems, summary reports of monitoring results, and database/data archiving services. These services are offered free of charge. TFW method manuals are available for the following surveys:

TFW Manuals

- Stream Segment Identification
- Reference Point Survey
- Habitat Unit Survey
- Large Woody Debris Survey
- Stream Temperature Survey
- Spawning Gravel Composition Survey
- Spawning Habitat Availability Survey
- Spawning Gravel Scour Survey
- Wadable Stream Discharge Meas. Method

To find out more about TFW Monitoring Program services and products, contact us or visit our link on the NWIFC homepage. The address is:

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2. Study Design

This section discusses several aspects of designing stream temperature monitoring studies, including study designs based on project objectives, selection of monitoring stations and thermal reaches, appropriate monitoring periods, selecting temperature recording instruments, survey modification options, and pre-season crew training and quality assurance reviews. The goal is a well-designed temperature monitoring study that is able to detect changes in stream temperature over time due to specific land management practices or natural disturbances. Effective monitoring study designs require rigorous planning, documentation, and consistency in methods, method application, and data analysis. This ensures that the monitoring data produced meets the objectives of the project and monitoring plan.

2.1 Study Design Based on Project Objectives

When designing a temperature monitoring study, it is important to carefully identify the monitoring objectives. For the project to be successful, it must be designed to achieve these objectives. Common objectives of temperature monitoring studies on forest lands include assessing and monitoring stream reaches of importance for aquatic resources, determining the stream temperature response to a land-use activity or natural event, and characterizing stream temperature regimes throughout a watershed. Data on the maximum stream temperature regime is needed to achieve any of the study design options discussed below.

2.1.1 Monitoring Stream Reaches of Importance to Aquatic Resources

If the monitoring objective is to assess and monitor stream temperature in reaches of importance to aquatic resources, then the first step is to identify stream reaches of concern. For example, if the objective is to monitor maximum stream temperature in stream reaches used by a particular salmonid stock, then stream segments utilized by sensitive life history stages of that stock need to be identified. Typically, maximum stream temperature is an issue in areas utilized for summer rearing by species that rear in fresh water streams such as coho, steelhead/rainbow, and chinook, cutthroat and bull trout. Reaches used for adult migration and holding during the summer or early fall by species such as spring and summer chinook, summer chum, and pink salmon may also be of concern. Other reaches of concern may be identified on the basis of other aquatic resource issues, such as reaches known to exceed water quality criteria for maximum stream temperature. Once a list of candidate monitoring reaches has been compiled based on the project objectives, a sampling plan can be developed. If only few reaches of concern are identified, it may be feasible to monitor all of them. If there are many, it is necessary to prioritize them and sample the most important, or stratify them on the basis of morphology and riparian condition and sub-sample each stratum.

2.1.2 Determining the Response to Land-Use Activities and Natural Events

If the monitoring objective is to test the effects of a land management activity (e.g. riparian timber harvest) on the temperature regime of a stream reach, several monitoring approaches are available. The preferred approach involves comparing stream reaches affected by the "treatment" with similar, undisturbed stream reaches. Either a before/after, upstream/downstream, or paired stream reach design may be used. If none of these approaches are feasible, then post-treatment temperature regimes can be compared to a target such as the state water quality standards to determine effectiveness. This approach is less desirable because the temperature conditions observed may be due to factors other than the treatment being evaluated.

The before/after approach requires monitoring of the affected stream reach both before and after treatment. The pre-treatment data provides the control against which the post-treatment results are compared to determine if a change occurred due to the treatment. The minimum data required is one summer before and after the treatment. This design requires the assumption that minor year to year climatic variability is inconsequential to stream temperature conditions, since the maximum equilibrium stream temperature is independent of minor fluctuations in regional air temperature maximums. Rather, the maximum equilibrium temperature of a given stream reach is dependent primarily on riparian conditions as they affect local air temperature, solar radiation, and relative humidity. Major variation in regional summer weather and air temperature would invalidate the assumption of year to year comparability. If both the before and after monitoring periods are representative, then the comparison is valid and incremental temperature change can be assessed. This can be checked by reviewing regional NOAA weather station records. It is better to gather more than one year of pre-treatment data if possible, in case unusual weather conditions occur.

The upstream/downstream and paired stream reach designs can be done in a single summer. The upstream/downstream design involves sampling at two stations, one at the lower end of the affected stream reach and another above the treated areas. The temperature regimes at the two stations are compared using the upstream reach as the control to determine if the temperature changed as a result of the management activity. The paired stream reach approach is similar, except a separate, undisturbed stream reach is used as the control. For both designs, the control and treatment reach must be of similar geomorphology, elevation, drainage area and discharge, so that differences in temperature between the two reaches is due to the treatment effect. Significant differences between the control and treated reach would invalidate this assumption.

Comparing post-treatment temperatures with a target value such as the state water quality standards or the preferred temperature range for a particular species of fish is the simplest approach to implement because only one monitoring station is required to monitor the treated reach. This approach is suitable for determining the status of the reach relative to the target following the treatment, but is inconclusive in attributing the condition to the treatment because there is no control for comparison. This type of study requires that information on the characteristics of the thermal reach be collected to determine the influence of canopy closure and channel characteristics on stream temperatures.

2.1.3 Characterizing Stream Temperature Patterns Throughout a Watershed

The third type of project objective involves characterizing stream temperature regimes on a watershed scale. To accomplish this objective, a typical approach is to stratify stream segments on the basis of channel morphology (gradient, confinement, channel width, or geomorphology), riparian stand condition (species, age, adjacent land-use), and other factors that affect temperature regimes (elevation, lakes, wetlands). Once stratified, temperature data is collected in a sub-sample of each stratum. This provides a representation of the temperature regimes for each class of stream segments in the watershed. Consultation with a statistician is recommended to develop a suitable sampling plan.

2.2 Selecting Sites to Establish Monitoring Stations

Once the monitoring reaches have been identified, a suitable location to establish monitoring stations in each segment must be identified. In some cases, the monitoring station location is determined by the location of the activity being monitored. For example, if a riparian harvest unit is being monitored, the temperature monitoring station should be located at the downstream end of a timber harvest unit. In other cases, there may be a choice of monitoring locations within a stream reach of interest. In these cases, it is preferable to establish monitoring stations near the downstream end of a thermal reach.

A thermal reach has relatively homogeneous stream and riparian conditions for a sufficient distance upstream from the monitoring station to allow the stream temperature to reach equilibrium with those conditions (Sullivan et al, 1990). The identification of a homogeneous thermal reach is based on the consistency of those channel and riparian conditions that affect stream temperature, such as canopy closure, channel width and depth, and tributary inflow. As a general guideline, significant variations in channel and riparian conditions comprising less than 10 percent of the thermal reach length are acceptable. Aerial photos are helpful in the assessment of stream reach conditions.

The length of stream required for water temperature to attain thermal equilibrium depends on stream size (especially water depth) and morphology. A number of factors have been correlated with stream temperature including stream shading, mean air temperature, elevation, stream discharge and channel width (Doughty et al., 1991). A deep stream responds more slowly to heat inputs and requires a longer thermal reach, while a shallow stream will generally respond more rapidly, requiring a shorter thermal reach. As a rule of thumb, it takes about 600 meters (2000 feet) of similar conditions to establish thermal equilibrium within a thermal reach (Sullivan et al., 1990; Rashin and Graber, 1992).

If the reach above a monitoring site has highly variable riparian or stream channel conditions (such as a tributary confluence or major changes in riparian vegetation), the temperature at that site can still be determined. However the temperature data will characterize localized conditions as opposed to conditions of a representative thermal reach. In other words, the stream temperature at that site is likely to be in a state of flux, either increasing or decreasing in order to come into equilibrium with changing conditions.

2.3 Determining Monitoring Parameters

The TEMP Survey provides instructions for collecting water temperature information at temperature stations, optional station air temperature information, and optional information on the station's upstream thermal reach characteristics. Decisions concerning the type of data to be collected is guided by the study objectives and the monitoring question to be answered.

Air temperature data is useful for evaluating the influence of summer air temperature on the water temperature readings and to help identify and interpret anomalies or drift in the water temperature readings. Air temperature information is also useful to assist in characterizing stream temperature patterns throughout a watershed.

Data on thermal reach characteristics immediately upstream of the temperature station is useful for evaluating the effect of environmental conditions such as shade, gradient, groundwater input and RMZ characteristics on water temperature readings at the temperature station. This information is particularly useful for monitoring studies designed to determine the response of stream temperatures to land-use activities and natural events or to characterize stream temperature patterns throughout a watershed. However, collection is optional since this information may not be necessary to achieve limited monitoring objectives and collecting it requires additional equipment and effort.

2.4 Determining the Monitoring Period

To determine maximum equilibrium temperature (i.e. maximum annual temperature) of the reach, the minimum monitoring period is from July 15 to August 15. However, in many areas (e.g., Eastern Washington), it is better to extend the period from late June until mid September. Use local knowledge to determine the best monitoring period. Monitoring may also be conducted at other times of the year for purposes such as characterizing temperature regimes during biologically significant periods for specific aquatic organisms or documenting winter low temperatures.

2.5 Selecting Temperature Recording Instruments

The choice of the temperature measurement instrument and the frequency that readings are taken is guided by the frequency and reliability of water temperature readings necessary to meet the study objectives. Stream temperature data can be collected with data loggers, maximum/minimum, or maximum thermometers. Data loggers are preferable because they provide a continuous record that can be used to determine daily maximums and minimums. They record temperature information electronically so it can be directly downloaded onto personal computers using the manufacturer software. The two most common types of data loggers are those with probes and those that are completely submersible. Maximum/minimum (Max/Min) and maximum thermometers can also be used to determine the peak temperatures during the monitoring period, however they do not provide a continuous temperature record. They only document the minimum and/or maximum temperatures during the period between visits, so the resolution of the data is determined by the frequency of visits to the site. One advantage of Max/Min and Max thermometers has been the relatively low cost per instrument. However the generally lower cost of the new type data loggers as compared to the cost of frequent crew field time required for Max/Min studies makes use of these systems more feasible.

2.6 Survey Modification Options

Data collected using the TEMP Survey methods are supported by the TFW-MP database and are used to produce standard data analysis summary reports. Data collected using these methods can be compared with other data collected using the same methods from around the state. Modifying the TEMP Survey to collect data on additional parameters that meet individual cooperator needs is acceptable if it does not compromise the integrity of the core parameters. Survey modifications are defined as any change to the core criteria and methods as documented in the latest version of the TFW method manual. In other words, data collected using the modified method would not be comparable at some level with data collected using the methods and criteria as stated in the manual. Analysis of modified data is the responsibility of the cooperator. Contact the TFW Monitoring Program for assistance in modifying the methods to ensure data integrity and compatibility.

There are two levels at which modification documentation is important. The first is to qualify data collected on the field forms and the second is to qualify data entered into the TFW database. Documentation in the *Survey Notes* sections of Form 8.0 allows accurate interpretation of field data. It is feasible to have the field forms flagged as modified, but not the database where core data has been extracted by the cooperator before data entry. Documentation of modification in the database allows accurate interpretation of affected parameters and calculations on summary reports. However, in most situations modified data cannot be entered into the database due to validation checks.

The field forms provided in the manuals have been designed for consistent and accurate recording of TEMP Survey data. The forms have been refined based on research and monitoring experience to reduce data errors caused by factors such as legibility, required parameter field calculations, and data transfer during database entry. The field forms can accommodate the collection of additional parameter data, thus limiting the necessity of cooperators to modify or create new forms.

2.7 Pre-Season Crew Training and Quality Assurance Review

Cooperators are strongly encouraged call the TFW Monitoring Program to make appointments for pre-season training and quality assurance (QA) reviews. Use of these services ensures that field crews are applying survey methods correctly from the start and the highest quality data is being collected throughout the survey. Training should be repeated annually to learn new methods, techniques, or simply refresh skills. QA reviews should be repeated seasonally to maintain documentation and to refresh survey skills.

3. Pre-Survey Preparation

This section describes what and how to gather, prepare, and pack for transportation all necessary survey equipment and materials required for field crews to complete the field portion of the TEMP Survey. These lists are not intended to cover all possible survey equipment and materials that could be of use.

3.1 Survey Equipment

Acquire, check, and calibrate survey equipment well before the date the survey is scheduled to begin. The following list of survey equipment contains items necessary for crews to conduct the TEMP Survey. The equipment includes:

Survey Equipment

Calibration
- All thermometers and temperature data loggers/probes to be used in the project
- Computer & software for launching & downloading data loggers
- Certified reference thermometer
- (1) 2-5 gallon container
- Stirring paddle and/or aquarium air pump system
- Ice (if using ice bath technique)
- Magnet (for use with max/min thermometers)

Temperature Station Surveys
- Temperature measurement instruments
- Instrument anchoring devices
- Calibrated pocket thermometer
- Measurement tape (30 - 50 m: accuracy ± 0.10 m)
- Measuring rod (5 - 7 m: accuracy ± 0.01 m)
- Spherical Densiometer
- Hip chain
- Standard field and vehicle gear (Appendix C)

Thermal Reach Surveys
- All temperature station survey equipment
- Weighted flags (6-12)
- Abney level, pea level, or surveying level
- Flowmeter system

The TFW-MP database will accept temperature data in degrees Celsius or Fahrenheit. All other parameter measurements entered into the database must be in metric units. Mixing measurement unit types (metric/English) within a survey is strongly discouraged due to potential for multiple conversion errors. If using English units, all measurements (except temperature data) must be converted to metric units before entry into the TFW-MP database. The cost of purchasing metric equipment is often offset by savings in personnel time and effort required to convert from English to metric units. It also results in the highest quality data due to avoidance of errors during conversion of large data sets.

Check all measurement equipment for damage before using. Calibrate all measurement equipment to a standard of known accuracy before and after the survey to ensure that the instruments provided accurate data during collection. A certified reference thermometer is required for the calibration process. Certified reference thermometers are at a minimum individually calibrated against National Institute of Standards and Technology (NIST) traceable equipment and have a certificate bearing the seal of the institute outlining individual tests and results. The Washington Department of Ecology recommends using a certified thermometer that has been calibrated at a minimum of two temperature points which bracket the expected stream temperature range. These thermometers are expensive and are not recommended for field use. The TFW Monitoring Program has a certified thermometer that can be loaned to TFW cooperators.

Anchoring devices are used to secure the data loggers and/or thermometers at the temperature station to maintain a constant temperature instrument position in the water or above the floodplain. They need to be sturdy enough to prevent scouring out during summer storm events, but small enough and/or camouflaged to prevent easy detection where vandalism is a problem. Typical equipment includes rebar stakes (½ inch diameter by 24 to 36 inches), stainless steel cable with cable locks, heavy duty nylon lock-ties, and duct tape. A small mallet and/or fencepost driver, wrenches, pliers, and wire cutters are used to drive the rebar into the channel bed and tighten or trim locks and cables. Identification tags are useful for others to return accidentally displaced or lost equipment. For example, one Hobo data logger in a sealed case was returned two years after it was lost, floated down the river and out to sea, and eventually found by a beachcomber (Taylor, pers. com., 1999).

Select wading gear to accommodate stream and survey conditions. Plan to get wet as anchors and instruments must be installed underwater. On most streams, having one crew with chest waders is important for installing, taking measurements, and removing temperature instruments. However, it is important to note that use of chest waders in fast flowing streams can be dangerous.

3.2 Survey Materials

Survey materials are those items necessary for crews to locate and document the temperature station location and access points, site conditions, and for recording field data. This list does not cover all possible materials. The basic materials include:

Survey Materials

- USGS 7.5 minute topographic map photocopy worksheet
- State water quality standards list (Appendix E)
- Thermal reach studies: Stream Gradient Measurement Method (Appendix F)
- Road map
- Copy of Segment Identification Form 1
- Aerial photos of site
- Copy of Temperature Form 8.0 (All Surveys)
- Copy of Temperature Forms 8.1 L, 8.2, and 8.2L (Data Logger Station Surveys)
- Copy of Temperature Forms 8.1 M, 8.2, and 8.2M (Max/Min Station Surveys)
- Copy of Temperature Forms 8.1 L, 8.2, 8.2L, 8.3, and 8.3R (Thermal Reach Surveys)

Start by gathering and organizing site access information and working on logistical factors. Obtain directions and maps; contact landowners and secure permission to access property; acquire necessary permits and passes; and determine if the access roads are gated and get gate keys or make necessary arrangements with landowner to provide access. Next, begin the survey documentation by preparing and completing header and preliminary information on the field data forms. Refer to Appendix B for examples of completed field forms.

3.2.1 TEMP "HEADER INFORMATION" Form 8.0

One Form 8.0 is completed for each temperature station. Use the Form 8.0 copy master to make a copy on regular white paper (Figure 1). Most header information can be copied directly from the segment's completed Form 1. The Water Resource Inventory Area number (WRIA #), unlisted tributary number (Unlisted Trib), segment number (Segment #), Sub-Segment Code, Temperature Station #, and Begin Survey Date are key fields used to identify unique monitoring stations for the TFW-MP database. Refer to the Stream Segment Identification method manual for more information if needed (Pleus and Schuett-Hames, 1998a).

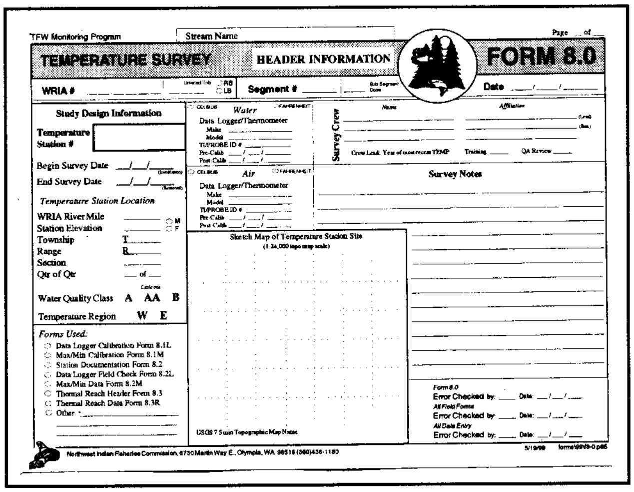

TFW Monitoring Program | Stream Name | Page __ of __
TEMPERATURE SURVEY | HEADER INFORMATION | FORM 8.0
WRIA # | Unlisted Trib | RB / LB | Segment # | Sub Segment Code | Date __/__/__
Study Design Information
Temperature Station #
Begin Survey Date __/__/__ (Installation)
End Survey Date __/__/__ (Removal)
Temperature Station Location
WRIA River Mile | Station Elevation (M / F)
Township T | Range R | Section | Qtr of Qtr __ of __
Water Quality Class A AA B
Temperature Region W E
Forms Used:
Data Logger Calibration Form 8.1L
Max/Min Calibration Form 8.1M
Station Documentation Form 8.2
Data Logger Field Check Form 8.2L
Max/Min Data Form 8.2M
Thermal Reach Header Form 8.3
Thermal Reach Data Form 8.3R
Other
Water (Celsius / Fahrenheit): Data Logger/Thermometer, Make, Model, TI/PROBE ID #, Pre-Calib, Post-Calib
Air (Celsius / Fahrenheit): Data Logger/Thermometer, Make, Model, TI/PROBE ID #, Pre-Calib, Post-Calib
Survey Crew: Name | Affiliation
Crew Lead: Year of most recent TEMP Training | QA Review
Survey Notes
Sketch Map of Temperature Station Site (1:24,000 topo map scale)
USGS 7.5 min Topographic Map Name
Form 8.0 Error Checked by: Date:
All Field Forms Error Checked by: Date:
All Data Entry Error Checked by: Date:
Northwest Indian Fisheries Commission, 6730 Martin Way E., Olympia, WA 98516 (360)438-1180

Figure 1. TEMP Survey "HEADER INFORMATION" Form 8.0.

Header Section

Stream Name: Record the WRIA-designated stream name. Use "Unnamed" where appropriate.

WRIA #: Record the six digit Water Resource Inventory Area (WRIA) number (00.0000).

Unlisted Trib: Only streams without assigned WRIA numbers require unlisted tributary numbers. For streams with WRIA numbers, fill this space with three zeros (000). For unlisted tributaries, record the previously identified three digit cooperator-designated unlisted tributary number (001 - 999) and mark the appropriate right or left bank (RB/LB) circle.

Segment #: Record the one to three digit segment number (1 - 999).

Sub-Segment Code: If the survey reach is a sub-segment, record the number or letter character sub-segment code (1 - 99 or a - zz). Record a "0" if not a sub-segment.

Date: Enter the date this form is being filled-out.

Survey Crew Section

Record the names and affiliations of the lead, recorder, and other field crew involved in data collection for the survey. Affiliations correspond to employers such as a tribe, government agency, industry, environmental group, consulting company, etc. Record the most recent year that the lead crew person received official TFW Monitoring Program on-site and/or annual workshop TEMP Survey training, and/or a QA Review. Note any other relevant training or field experience in the *Survey Notes* section.

Study Design Information Section

Temperature Station Number: Record a one- to eight-number/character temperature station number. The temperature station number is a unique identifier that is designated by the cooperator (e.g., 12345678; 3-14; White4; or 11Ohop).

Begin/End Survey Dates: Record the installation and removal dates from Form 8.2. The beginning and ending dates correspond to when the water temperature instrument(s) at this station were installed and removed from the field. The *Begin Survey Date* is a key database field used to track and identify this specific survey.

Temperature Station Location: Use methods described in the TFW Segment Identification Method to determine the temperature station's location by WRIA River Mile, station elevation, township, range, section, and quarter of quarter descriptors (Pleus and Schuett-Hames, 1998a).

Water Quality Classification of the Reach: Circle either class A, AA, or B. Refer to Appendix E to determine the water classification. Specific streams may be listed by name in Section 130, or by the classification of the water body they drain into. Some sub-sets of streams are classified according to their location (for example, all streams within national forests, national parks, or wilderness areas are Class AA).

Temperature Region: Determine whether the site is located in the Western Washington or Eastern Washington temperature region (Appendix G). These regions generally correspond to Water Resource Inventory Area (WRIA) basin boundaries (WFPB 1996).

Forms Used Section

Record, when known, all types of TEMP field forms used for this survey by marking the circles adjacent to the form type. Where appropriate, mark the Other circle and record form or documentation type.

Water and Air Temperature Instruments Section

Record, when known, the unit of measure, temperature instrument make, model, identification number (*TI/Probe ID #*), and the pre/post-calibration dates for both water and air temperature instruments used at this station. This information can be copied from Form 8.1L or 8.1M when calibration has been completed. If no air temperature instrument is used, cross out the box.

Sketch Map of Temperature Station Site Section

This sketch map provides information on the geographic location of the temperature station and driving directions to the walking access points. The easiest technique is to paste a copy of the USGS 7.5 minute topographic map section with the temperature station and/or thermal reach locations marked.

Survey Notes Section

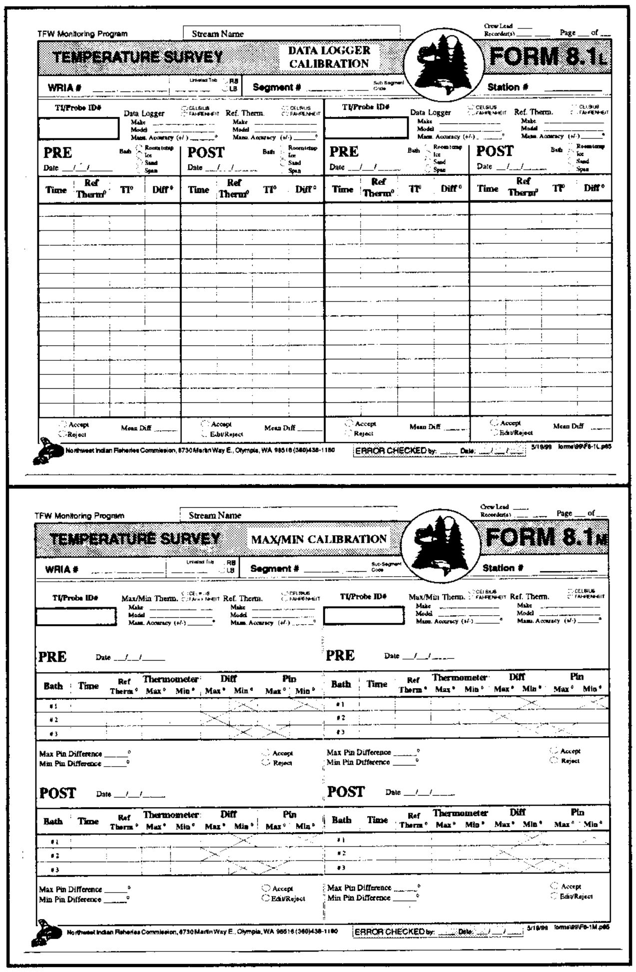
Record driving and access directions sufficient for a person unfamiliar with the area to locate the temperature station area. This section is also used to provide brief notes related to unique survey conditions and problems encountered. Note any additional parameters and modifications made to the TEMP Survey procedure used to meet individual cooperator needs. Additional information can be included on the back of the form or on separate sheets of paper.

Error Checking Documentation Section

Instructions for completing the section on documenting error checking procedures (lower right-hand comer of form) will be covered in the Post-Survey Documentation section.

3.2.2 TEMP "DATA LOGGER CALIBRATION" Form 8.1L, and TEMP "MAX/MIN CALIBRATION" Form 8.1M

Use the Form 8.1L or 8.1M copy master to make multiple copies on regular white paper (Figure 2). This provides pre- and post-survey calibration documentation for a specific temperature station and up to two data loggers or standard thermometers, or one logger/thermometer using two different baths.


TFW Monitoring Program
Stream Name
TEMPERATURE SURVEY
DATA LOGGER CALIBRATION
FORM 8.1L
WRIA #
Segment #
Station #
PRE
POST
ERROR CHECKED by: ___ Date: _/_/_

TFW Monitoring Program
Stream Name
TEMPERATURE SURVEY
MAX/MIN CALIBRATION
FORM 8.1M
WRIA #
Segment #
Station #
PRE
POST
ERROR CHECKED by: ___ Date: _/_/_

Figure 2. TEMP Survey "DATA LOGGER CALIBRATION" Form 8.1L and "MAX/MIN CALIBRATION " 8.1M.

Record the *Stream Name/WRIA #/Unlisted Trib/Segment #/Sub-Segment Code/Station #* as documented on Form 8.0. Record the initials of the crew lead, recorder, and other crew in the spaces provided in the upper right-hand comer. Leave the *Page __ of __* space blank as recorded at the time of the calibration. The rest is completed at the time of the calibration.

3.2.3 TEMP "STATION DOCUMENTATION" Form 8.2, TEMP "DATA LOGGER FIELD CHECK" Form 8.2L, and TEMP "MAX/MIN DATA" Form 8.2M

Use the Form 8.2 and 8.2L or 8.2M copy masters to make one copy per temperature station on waterproof paper (Figure 3). Record the *Stream Name/WRIA #/Unlisted Trib/Segment #/Sub-Segment Code/Station #* as documented on Form 8.0. Record the initials of the crew lead, recorder, and other crew in the spaces provided in the upper right-hand comer. Leave the *Page __of__* space blank as it is recorded at the time of the field installation.

3.2.4 TEMP "THERMAL REACH SURVEY DESCRIPTION" Form 8.3 and TEMP "THERMAL REACH CHARACTERISTICS " Form 8.3R

Use the Form 8.3 copy master to make one copy per thermal reach on regular paper and Form 8.3R copy master to make one copy on regular paper for additional copying purposes (Figure 4). Record the *Stream Name/WRIA #/Unlisted Trib/Segment #/Sub-Segment Code/Station #* as documented on Form 8.0. Record the initials of the crew lead, recorder, and other crew in the spaces provided in the upper right-hand comer. *Page __ of __* and *Date* items are recorded when reach information is first collected. Instruction on completing the *Thermal Reach Information, Equipment, Sketch Map,* and *Reach Notes* boxes on Form 8.3 will be covered in the *Thermal Reach Data Collection* manual section. After completing the information listed above on Form 8.3R, use this to make multiple copies on waterproof paper for field thermal reach data collection.

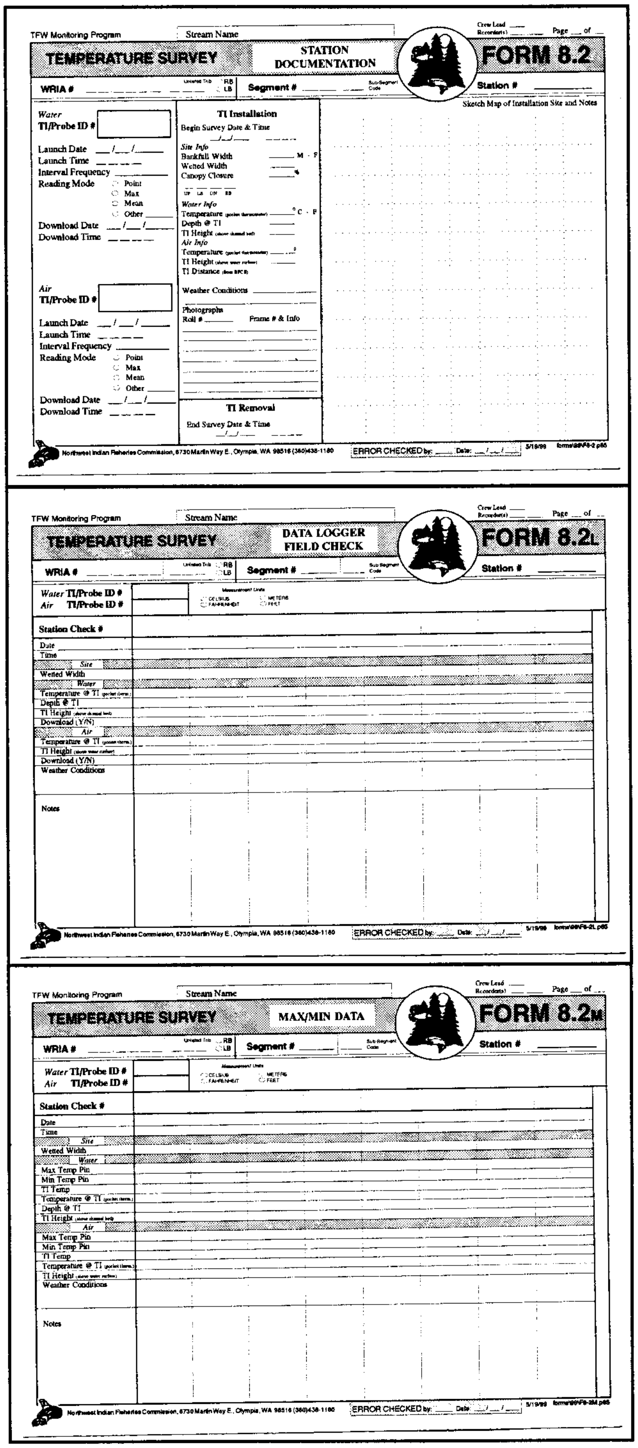


Figure 3. TEMP Survey "STATION DOCUMENTATION" Form 8.2, "DATA LOGGER FIELD CHECK" Form 8.2L, and "MAX/MIN DATA" Form 8.2M.

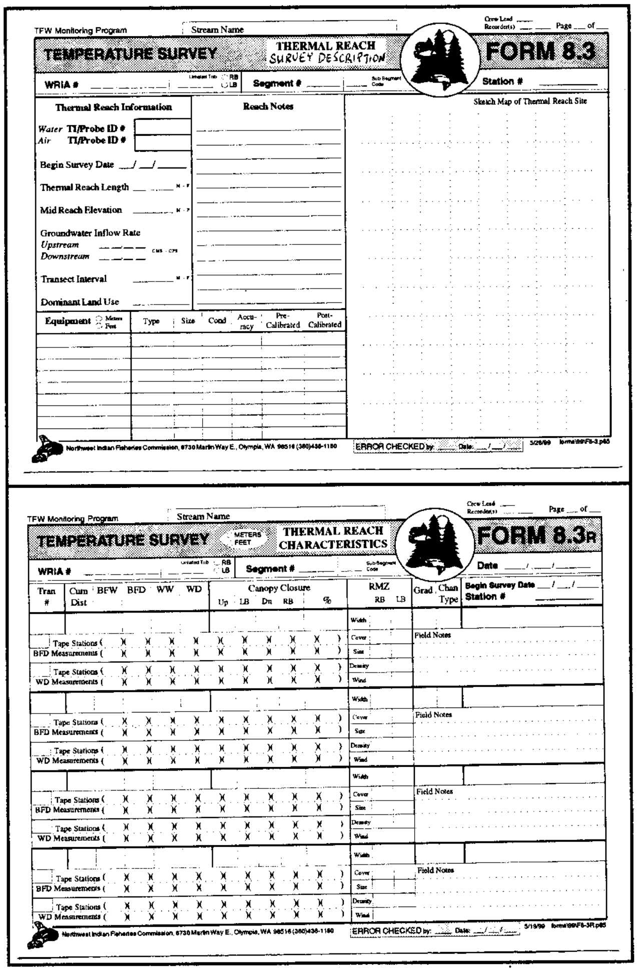


Figure 4. TEMP Survey "THERMAL REACH SURVEY DESCRIPTION" Form 8.3, and "THERMAL REACH CHARACTERISTICS" Form 8.3R.

3.3 Calibrating Temperature Instruments

Pre-survey calibration is required for each thermometer and data logger to ensure the reliability of the data it records and provide QA Plan documentation. Calibration should occur immediately prior to installation of the instruments (i.e., last season's post-calibration isn't acceptable). This section discusses the minimum calibration procedures for thermometers and data loggers. Enhancement of the calibration process is recommended by running multiple calibration checks with different temperature water baths or by recording a "zero to span" range of temperatures over many hours.

3.3.1 Calibration Bath Preparation

The first step for calibrating either data loggers or maximum/minimum thermometers is to prepare the calibration bath. The materials for the baths should be gathered ahead of time. The following procedures describe how to create and maintain two types of temperature calibration baths.

Room temperature water bath: Fill a container (insulated for data loggers, non-insulated for Max/Min thermometers) with water and let it sit overnight in a room where air temperature can be kept constant. This means areas that do not have traffic flow, constant air temperature changes from doors opening, etc. Five minutes prior to inserting the temperature measurement instruments, begin mixing the water bath and continue to mix during calibration to avoid temperature stratification. Mixing can be accomplished manually with a stirring stick or spoon, or by using an aquarium air pump and an air stone (two systems with larger containers).

Ice water bath: When temperature instruments are ready to placed in the bath (see below), fill an ice chest 1/3 to ½ full of ice. Place the data loggers on the ice and cover with additional ice until filled. Add water and additional ice if necessary until the water level is even with the top of the ice. Standard thermometers are inserted from the top of the ice bath so that they can be retrieved for reading. Let stand at least 15 minutes for the instruments to reach equilibrium with the bath water. Five minutes prior to starting, begin mixing the water bath until a uniform water temperature at or near zero degrees Celsius (32 degrees Fahrenheit) is achieved as measured using the reference thermometer. Continue to mix the water column during the calibration procedure to maintain a constant temperature. Ice must always be present in the bath to maintain equilibrium. Mixing can be accomplished by using an aquarium air pump (two or more with larger containers) and an air stone (insert prior to adding ice) or manually (gently) with a stirring stick.

3.3.2 Calibration Procedure for Data Loggers

The minimum calibration procedure is to record reference thermometer and temperature instrument readings at 10 points over time using one constant temperature bath. The mean difference in readings at each point in time constitute the accuracy range or bias of the instrument and how the temperature data collected during the field season will be analyzed.

Preparation

Make sure batteries have enough charge to last through the monitoring period or install new batteries at this time. Changing batteries later will require another calibration. Check to make sure data loggers are functioning properly. If the data loggers have detachable temperature probes, each data logger and probe is paired for calibration in the same combinations as they will be deployed for monitoring and marked with a unique identification code.

Data loggers need to be "launched" prior to calibration. Although instruments vary, the launching process basically turns the temperature instrument on, synchronizes its clock with the computer's clock, and allows the user to set the temperature reading frequency. Check to make sure the logger isn't set to delay launch. Set temperature recording frequency to a one minute or less measurement cycle. Check to verify date and time are correct on logger. Synchronize the calibration timer to be used with the reference thermometer to the launch computer's clock. If selecting the reading mode is an option, set the data logger to take point temperature readings rather than averages over the cycle time during the calibration procedure.

Form 8.1L is used to document the calibration procedure for data loggers and standard thermometers. Refer to Appendix B for an example of a completed Form 8.1L. Record the logger and probe (if applicable) identification number. Where multiple probes are used with a single data logger, complete a separate pre/post section on the form (i.e., *TI/Probe ID #* 0057/3, and 0057/4). Record the unit of measure, make, model, and manufacturer's stated accuracy. Check all connections and cables for corrosion, moisture, cracks, frays and breaks. Record the reference thermometer unit of measure, make, model, and manufacturer's stated accuracy. Check the reference thermometer for damage and air bubbles in the mercury. Record the date of the calibration and the type bath used in the pre-survey column.

General Procedure

Place the temperature instruments in the calibration bath, along with the certified reference thermometer. Instruments should not contact the walls of bath containers. Data logger, probes, and/or standard thermometers need to be situated at the same water level as the reference thermometer sensor bulb. Probes and standard thermometers can be bundled together with the reference thermometer. Agitation of room temperature and ice water baths is required to maintain a uniform temperature throughout the bath. It takes only 1-2 minutes for a bath to develop temperature layers.

After inserting instruments into the calibration bath, wait a minimum of 15 minutes to allow the instruments to reach equilibrium with the bath temperature. Temperature readings are taken at a minimum of one minute intervals. Times can be pre-designated and recorded in the *Time* column. When multiple data loggers or thermometers are being calibrated in the same bath, record the reference thermometer reading in the *Ref Therm⁰* column on only one form. These readings can be transferred to the individual TI/Probe forms later. Begin the calibration process at the start of a new minute (e.g., 1001, 1002, 1003, etc.). Standard thermometers are read at this time and recorded in the *TI⁰* (temperature instrument in degrees) column. Never remove the sensor bulb from the bath when reading a thermometer. Always return thermometers to the same water level after reading. Repeat at minimum one minute intervals for 10 minutes or longer and mark the results on each subsequent line.

After completing all reference thermometer readings, data loggers must be downloaded according to manufacturer instructions and data read off the screen and/or printed out. A graph of the temperature readings over time provides additional documentation for the calibration files. Find the temperature data times corresponding to the reference thermometer readings and record those temperatures in the *TI⁰* column on corresponding time rows.

The differences between the reference thermometer and data logger are now ready to be calculated for each time. Subtract the *TI⁰* readings from the *Ref Therm⁰* readings for each row and record the result in the *Diff⁰* (difference) column. Finally, calculate the mean difference by adding all the numbers in the *Diff⁰* column together and dividing the result by the number of readings. Record this number in the *Mean Diff* blank at the bottom of the section.

Any instruments that vary by more than two degrees Celsius or Fahrenheit from the reference thermometer must be rejected until the problem is corrected and they pass a subsequent calibration test. Unacceptable calibration results may be due to many factors including defective equipment, improper temperature bath procedure, inconsistent thermometer readings, or a defective reference thermometer. To identify what may be causing calibration problems, use a process-of-elimination procedure. Try a different probe, data logger, or reference thermometer. If using a room temperature bath, try an ice bath. Those units not at or near zero degrees Celsius are probably the problem. Mark the *Accept* or *Reject/Repair* circle at the bottom of the box. It is important to document rejected equipment for QA Plan purposes. Repair or replace any defective equipment according to manufacturer directions and repeat the calibration procedure.

3.3.3 Calibration Procedure for Max/Min Thermometers

Calibration of Max/Min thermometers requires a three-step overnight procedure. The difference in readings at each point in time constitute the accuracy range or bias of the instrument and how the temperature data collected during the field season will be analyzed.

Preparation

Form 8.1M is used to document the calibration procedure for Max/Min thermometers. Refer to Appendix B for an example of a completed Form 8.1M. Mark each thermometer with a unique identification number or code and record this number in the *TI/Probe ID#* box. Record the unit of measure, make, model, and manufacturer's stated accuracy and check it for damage. Record the reference thermometer unit of measure, make, model, and manufacturer's stated accuracy and check it for damage. Record the date of the calibration.

General Procedure

Max/Min thermometers are "U" shaped, have two sets of temperature scales, and have marker pins built into the mercury column. The Max marker is pushed by the mercury column until it reaches its highest temperature of the day. When cooling starts, the mercury recedes and the maximum marker remains in place indicating the highest temperature reached. Check and adjust the scales on both sides of the thermometer so that the top of both mercury columns read the same temperature. As the temperatures cool, the mercury recedes making contact with the other marker and pushing it until the minimum temperature is reached. Marker pins are reset or "zeroed-out" by using a magnet to slowly pull the pin downward until it contacts the head of the mercury column. When taking readings or using magnets to zero-out Max/Min thermometers, keep the thermometer completely submerged so the air temperature will not change the reading. Maintaining the same angle of view for consistent readings is important with this instrument. Three bath treatments are used to represent a stream warming, cooling, and re-warming cycle.

Bath #1: Zero-out the thermometer. Place the temperature instruments with the top at least slightly elevated in the stable room temperature bath, along with the certified reference thermometer. Instruments should not contact the walls of bath containers. Max/Min thermometers need to be situated at the same water level as the reference thermometer sensor bulb. Agitation of the room temperature bath is required to maintain a uniform temperature. It takes only 1-2 minutes for a bath to develop temperature layers.

After 10 minutes, record the time (*Time*) and mercury readings from the reference thermometer (*Ref Therm*^{0}) and both the maximum and minimum sides of the thermometer (*Thermometer Max*^{0}*, Min*^{0}) in the Bath #1 row on Form 8.1M. Record the temperature at the maximum marker pin placement in the *Pin Max*^{0} column. Subtract the *Thermometer Max*^{0} reading from the *Ref Therm*^{0} reading and record the difference in the *Diff Max*^{0} column.

Bath #2: Using the same water bath and keeping the temperature instruments in the water, add a substantial amount of ice to bring the water temperature down to at or near zero degrees Celsius (32 degrees Fahrenheit). Mix the water bath to achieve and maintain a uniform water temperature. 30 minutes after starting the ice bath step, record the time and readings from the reference and Max/Min thermometers on the Bath #2 row.

Record the temperature at the maximum marker pin placement in the *Pin Max*^{0} column. Then record the temperature at the minimum marker pin placement in the *Pin Min*^{0} column. Subtract the *Thermometer Min*^{0} reading from the *Ref Therm*^{0} reading and record the difference in the *Diff Min*^{0} column. Subtract the *Pin Max*^{0} Bath #2 reading from the *Pin Max*^{0} Bath # 1 reading and record the difference on the *Max Pin Diff* __^{0} line.

Bath #3: Let the water bath sit overnight (minimum 8 hours) undisturbed at room temperature. In the morning, mix the water for five minutes. Record the time and readings from the reference and Max/Min thermometers on the Bath #3 row.

Record the minimum marker pin position. Subtract the *Thermometer Max*^{0} reading from the *Ref Therm*^{0} reading and record the difference in the *Diff Max*^{0} column. Subtract the *Pin Min*^{0} Bath #3 reading from the *Pin Min*^{0} Bath #2 reading and record the difference on the *Min Pin Diff* __^{0} line.

Reject Max/Min thermometers that are off by more than two degrees Celsius or Fahrenheit caused by either not tracking uniformly with the reference thermometer during calibration or where the maximum or minimum marker pins wandered during calibration.

Unacceptable calibration results may be due to many factors including defective equipment, excessive movement causing marker pin movement, improper temperature bath procedure, inconsistent thermometer readings, or a defective reference thermometer. To identify what may be causing calibration problems, use a process-of-elimination procedure. Mark the *Accept* or *Reject/Repair* circle at the bottom of the box. It is important to document rejected equipment for QA Plan purposes. Repair or replace any defective equipment according to manufacturer directions and repeat the calibration procedure.

Where differences are consistently off, many Max/Min thermometers can be manually adjusted to match the reading of the reference thermometer by following manufacturer's instructions. Alternately, readings from the Max/Min thermometers can be adjusted during data analysis using a correction factor based on the difference between the Max/Min thermometer and the reference thermometer recorded during calibration.

4. Stream Temperature Survey Methods

This section provides the criteria and procedures for conducting the Stream Temperature Survey and describes how to document information on temperature stations and optional thermal reach characteristics. It is organized in a sequential format to facilitate accurate and consistent application of the methods. This section can be copied for crews to take out into the field. Forms 8.2, 8.2L, 8.2M, 8.3, and 8.3R have been designed to record, organize, and track the information gathered using these methods.

The methods section is divided into two parts: 1) Temperature Station Data Collection; and 2) Optional Thermal Reach Data Collection. Temperature station survey procedures are required when conducting thermal reach studies. The TEMP Survey procedure will be explained as if a crew were conducting the survey for the first time at one temperature station and thermal reach. This procedure can be applied on a watershed level by systematically following the same methods station by station.

4.1 Temperature Station Data Collection

This section breaks the collection of temperature station information into steps including installation of temperature instruments, station installation documentation, periodic station checks, and removal of temperature instruments.

4.1.1 Installation of Temperature Instruments

Form 8.2 is used to document the installation process. When installing temperature data loggers or Max/Min thermometers, choose a location in the stream that is representative of the overall morphology of the reach. If pool habitat is common in the reach, choose a location in a representative pool. The instrument should be set in the stream so that it meets all of the following criteria:

Installation Criteria

1. Above the bottom to avoid groundwater inflow or temperature stratification influences;
2. deep enough to prevent exposure to air as the water level drops during the low flow period;
3. in an area with turbulent flow mixing; and
4. shaded from direct sunlight.

Installation of Data Loggers

Data loggers need to be re-launched prior to installation. This process removes the calibration data and allows resetting the recording frequency and mode. Otherwise, the shorter calibration frequency would fill the memory capacity before the end of the survey. Set recording frequency to take temperature readings at one hour intervals. If an option, select the logger mode to record maximum temperatures. Make sure the date and time modes are functioning properly.

There are two types of data loggers, those with external probes and those that are submersible. Data loggers with external probes are hidden on the bank above the high water mark with the probe extended by cable into the water to collect water temperature measurements. For submersible type data loggers, the recording instrument is either self-contained or enclosed in a water-tight canister that is placed directly into the stream.

It is often best to set the probe or submersible data logger canister at about one-half of the water depth and as close to the center of the thalweg as possible. The installation site is located in an area of obvious water mixing and at a depth where it won't become exposed if water levels drop. Avoid installing it on the channel bed bottom where it will be affected by groundwater inflow or stratification as noted above. Another good technique is to check the water temperature at several upstream and downstream locations to verify that the selected station is a representative area. Install the probe/ submersible data logger in a location where it will be shaded from direct sunlight. Shade can be provided by the canopy or some other feature such as large woody debris. If no shaded locations are available, it may be necessary to construct shade by placing the data logger or probe into a section of large diameter plastic pipe with holes drilled in it to allow water circulation and points of attachment to the anchor. This will protect the instrument from direct sunlight while allowing water to move through. Attach the probe or submersible data logger securely to a rebar stake, rock, root or stable LWD to keep it in place.

Vandalism and animal damage are common problems in stream temperature monitoring. Several measures can be taken to reduce the potential for loss or damage. When installing data loggers with probes, the logger should be placed outside of the bankfull channel to prevent loss during high flows. It can be housed in a waterproof metal or plastic box that is locked and chained to a tree, and covered with rocks, moss and wood to hide equipment from passersby. The canisters of submersible data loggers can be painted with a camouflage pattern to reduce the chance of detection.

Installation of Max/Min Thermometers

It is important to install Max/Min thermometers so that they are protected from turbulent flow conditions because excessive movement of the instrument can cause the marker pins to move. Build a rock cairn to a height of approximately 8-15 centimeters (3-6 inches) above the stream bed to house the Max/Min thermometer. Locate the cairn near the thalweg where uniform flows will give reliable temperature readings. The site should meet the criteria as stated above (be in an area of mixing, at a depth where it won't become exposed if water levels drop but not on the bottom where it will be affected by groundwater inflow or stratification).

Place the Max/Min thermometer in the stream and wait five minutes to allow the instruments to adjust to the water temperature. This is a critical step, otherwise the first maximum reading will be that of the air temperature. Zero-out the maximum and minimum marker pins with a magnet and lay the thermometer in the cairn with the top of the instrument slightly elevated. Place a single layer of rocks on top of the thermometer. If the stream is likely to experience flows high enough to scour substrate during the monitoring period, anchor the thermometer with string or wire to a large rock or stable material on the bank.

Installation of Optional Air Temperature Instruments

Install a second temperature instrument on the bank adjacent to the water temperature station to collect air temperature information at the temperature station. Install instruments one to three meters into the riparian zone from the edge of the bankfull channel and about one meter off the ground. The purpose of this information is to examine how air temperatures next to the stream effects water temperature and to increase the interpretive power of the water temperature data. Avoid placing the instrument in areas which do not represent immediate stream side conditions. Make sure the instrument is shaded from direct and indirect sun throughout the day, protected from precipitation, and hidden to avoid vandalism.

4.1.2 Station Installation Documentation

Documentation of installation conditions on Form 8.2 is important for your QA plan and for relocating temperature instruments during periodic survey checks and removal. Proper documentation prevents loss of survey time, equipment, and data. The order in which the installation data is collected is up to the crew at the time of the survey. Mark the circle next to the units of linear measure used during documentation as either meters (M) or feet (F), and temperature measure as either Celsius (C) or Fahrenheit (F).

Temperature Instrument Information

TI/Probe ID #: Record the same temperature instrument/probe identification number as used in the calibration procedure.

Unit Launch Date & Time: Record the date and military time that the data loggers were started, or will start (delayed launch) collecting stream temperature information. Data loggers use military time which is displayed as a 24 hour clock with 8:45 a.m. written as 0845 and 2:15 p.m. written as 1415. Leave blank for Max/Min thermometers.

Interval Freq & Reading Mode: Record the data logger temperature recording frequency (e.g., 0.5 hr., 1.0 hr., 1.5 hr., etc.) and reading mode (point, maximum, or average) over the frequency cycle. Leave blank for Max/Min thermometers.

Download Date & Time: Record when completed, the date and military time that the data loggers were downloaded after removal from the field. Leave blank for Max/Min thermometers.

TI Installation

Date and Time: Record the date and military time of actual temperature instrument placement in the water and air stations.

Site Bankfull Width: Record the bankfull width along a line intersecting the instrument placement in the water. Refer to the TFW Reference Point Survey (Pleus and Schuett-Hames, 1998b) for detailed instruction.

Site Wetted Width: Record the wetted width along the same line intersecting the instrument placement in the water.

Site Canopy Closure: Record the upstream, left bank, downstream, and right bank canopy closure at the center of the wetted channel along the wetted width measurement line. Calculate the percent canopy closure by adding the four readings together, dividing the sum by four, and multiplying the result by 1.04. Refer to the TFW Reference Point Survey for detailed instruction.

Water Temperature: Record the water temperature at the station using a calibrated pocket thermometer. Allow the thermometer to equilibrate at least 10 minutes in the water before reading. If using only one pocket thermometer for both water and air temperatures, collect the air temperature first to avoid a longer equilibration time.

Water Depth @ TI: Record the depth of the water from the channel bed to the water surface where the temperature instrument/probe is anchored.

Water TI Height: Record the height of the temperature instrument/probe above the channel bed where it is anchored.

Air Temperature @ TI: Record the air temperature at the air temperature station (or estimated location if no TI is installed) using a calibrated pocket thermometer. Tie the instrument to a branch in a shaded area as close to the station as possible. Allow the thermometer to equilibrate at least 10 minutes in the air before reading (20 minutes if water temperature was collected first on same instrument).

Air TI Height & Distance: Record the distance from the bankfull channel edge (BFCE) to the air TI (or the pocket thermometer) and its height above the water surface (water surface to BFCE + BFCE to TI).

Weather Conditions: Record the general weather conditions including cloud cover, precipitation, and wind.

Photographs: Record the roll and frame numbers, and frame information used to document the station and TI location.

Sketch Map of Installation Site and Notes: The sketch map is the key to temperature instrument relocation (Figure 5). It is the next level in detail after the sketch map made on Form 8.0. Sketch and note information includes direction of magnetic north, walking directions from vehicle parking, general location of the TI installation, right and left bank designations, flow direction, and easily identified local features such as flagging, stable trees/LWD, and distances/directions to access trails. Keep the map as simple as possible.

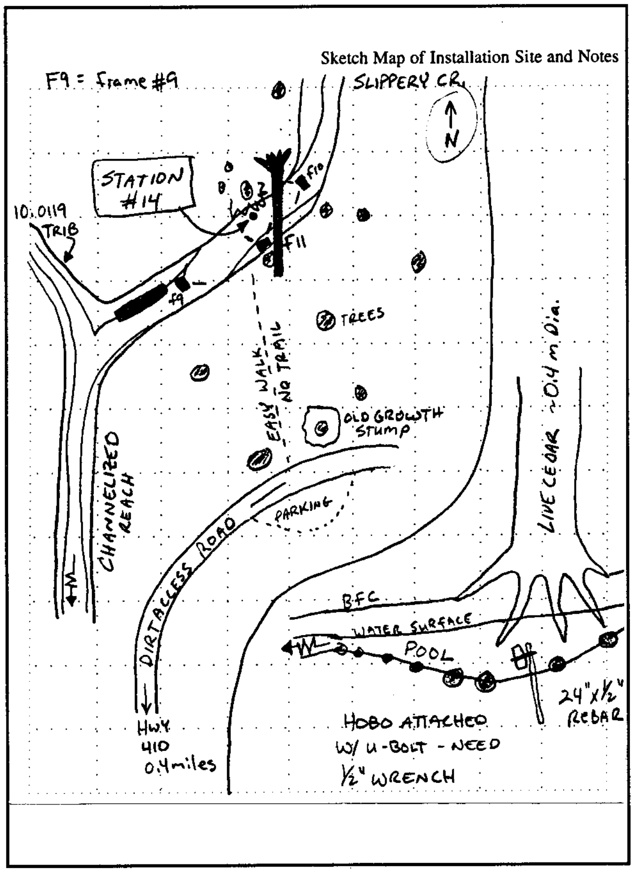


Figure 5. Detail of Form 8.2 "Sketch Map of Installation Site and Notes" section completed example.

4.1.3 Periodic Station Checks

The site should be visited periodically to collect station and/or temperature data and to make sure the instruments are in working order. During the summer season, temperature instruments can be damaged or lost due to vandalism, flooding, animals, or anchors becoming unfastened. Damaged instruments must be re-calibrated or replaced with another calibrated instrument. Bring extra pre-calibrated and launched instruments during these visits for quick replacement. Increasing the frequency of periodic checks will reduce the amount of data lost if a problem occurs.

Data Logger Station Checks

Stations should be visited in the morning or late afternoon to avoid disturbance during the peak temperature times. Two or three visits are recommended with more if the site is prone to disturbance. Some data loggers are designed so data can be periodically downloaded during field visits, reducing the risk of data loss.
Use Form 8.2L to collect periodic station check information. Mark the circle next to the units of linear measure used during documentation as either meters (M) or feet (F), and the temperature measure as either Celsius (C) or Fahrenheit (F).

Water & Air TI/Probe ID #: Record the same temperature instrument/probe identification number(s) as used in the calibration and installation procedures.

Station Check #: Record the number associated with the sum of visits to that point (i.e., 1 = first visit, 2 = second visit, etc.). This identifies the column to which station check information is associated.

Date: Record the date of the station check in month, day, year format.

Time: Record the start time in military units of station check information collection. Spot field measurements should not be expected to compare exactly with data logger records.

Site Wetted Width: Record the wetted width along a line intersecting the instrument placement in the water and perpendicular to the general flow.

Water Temperature @ TI: Record the water temperature at the temperature instrument using a calibrated pocket thermometer. Allow the thermometer to equilibrate at least 10 minutes in the water before reading. If using only one pocket thermometer for both water and air temperatures, collect the air temperature first to avoid a longer equilibration time.

Water Depth @ TI: Record the depth of the water from the channel bed to the water surface where the temperature instrument/probe is anchored.

Water TI Height: Record the height of the temperature instrument/probe above the channel bed where it is anchored.

Water Download: Record whether water temperature data was downloaded during the station check as either yes (Y) or no (N).

Air Temperature @ TI: Record the air temperature at the air temperature station (or estimated location if no TI is installed) using a calibrated pocket thermometer. Tie the instrument to a branch in a shaded area as close to the station as possible. Allow the thermometer to equilibrate at least 10 minutes in the air before reading (20 minutes if water was collected first on same instrument).

Air TI Height: If an optional air temperature TI is being used, record its height above the water surface (water surface to BFCE + BFCE to TI).

Air Download: Record whether air temperature data was downloaded during the station check as either yes (Y) or no (N).

Weather Conditions: Record the general weather conditions including cloud cover, precipitation, and wind.

Notes: Record any information related to temperature data quality such as disturbance, relocation, replacement, etc.

Max/Min Thermometer Station Check

Stations should be visited in the morning or late afternoon and preferably at the same time each day to avoid disturbance during the peak temperature times. The frequency of visits will affect the data you collect. By checking them every one to three days, you will be able to establish how often high temperatures are reached. Checking every day allows you to characterize the diurnal temperature range. If your objective is only to determine the maximum temperature that is reached over the monitoring period and you are not concerned with how often it is reached, you may leave the thermometers in the stream for up to one week without reading or resetting it.

Use Form 8.2M to collect periodic station check information. Mark the circle next to the units of linear measure used during documentation as either meters (M) or feet (F), and temperature measure as either Celsius (C) or Fahrenheit (F). Refer to the Data Logger Station Check section above for instructions on recording *TI/Probe ID #, Station Check #, Date, Time, Site Wetted Width, Water Temperature @ TI, Water Depth @ TI, Water TI Height, Air Temperature @ T1, Air TI Height, Weather Conditions*, and *Notes*. Additional information required for this check is listed below.

Water TI Max Pin: Record the temperature associated with the maximum pin marker placement.

Water TI Min Pin: Record the temperature associated with the minimum pin marker placement. After recording this information, the water TI can be zeroed-out with the magnet, returned, and secured in the rock cairn.

Water TI Temperature: Record the TI water temperature corresponding to the mercury line at the time of the station check. Remove the thermometer from the rock cairn and bring it as close to the surface as necessary to read and record the information. Max/Min thermometers should always be read and reset while in the water, so that air temperature does not influence the marker pins.

Air TI Max Pin: Record the temperature associated with the maximum pin marker placement.

Air TI Min Pin: Record the temperature associated with the minimum pin marker placement. After recording this information, the air TI can be zeroed-out with the magnet, returned, and secured in the previous anchoring spot.

Air TI Temperature: Record the TI air temperature corresponding to the mercury line at the time of the station check.

4.1.4 Removal of Temperature Instruments

Once the monitoring period is over, the instruments should be promptly removed. Delay in removing instruments at the end of the field season can result in loss of both instruments and data due to vandalism or high flows. Use the next station check column on Form 8.2L or 8.2M to document the removal conditions. Copy the removal date and time onto Form 8.2 in the *TI Removal* box.

4.2 Thermal Reach Data Collection (Optional)

This section describes how to collect optional thermal reach data on stream channel, riparian and watershed conditions to assess and help interpret factors influencing stream temperatures. Refer to the Study Design section above for guidance on selecting thermal reaches. Data loggers are the most common type temperature instrument used for this study, but Max/Min thermometers can be use with frequent station checks. Temperature station data collection procedures are required for both water and air temperature information when conducting a thermal reach study. In general, thermal reach data is collected during the temperature instrument installation phase.

4.2.1 Thermal Reach Survey Description

Form 8.3 is used to document information describing the thermal reach survey. The form is divided into sections for thermal reach information, equipment, reach notes, and sketch map of thermal reach site.

Thermal Reach Information Section

Water &Air TI/Probe ID #: Record the same temperature instrument/probe identification numbers as used in the calibration and installation procedures.

Date: Record the date for starting Form 8.3. This date may be different from the *Begin Survey Date* key field and is not entered into the database.

Thermal Reach Length: Record, when known, the total length of the thermal reach as calculated from the cumulative distance measurements during the survey (Form 8.3). The minimum recommended thermal reach length is 600 meters (2000 feet). Reach lengths should reflect transect interval frequency (i.e., 600, 625, 650, etc.; or 2000, 2080, 2160, etc.).

Mid Reach Elevation: Record the estimated elevation at the midpoint of the thermal reach based on USGS topographic map contour lines.

Groundwater Inflow Rate: Measure and record the downstream and upstream discharge. Discharge is measured using either the USGS (Rantz and others, 1982) or the TFW Wadable Stream Discharge Measurement Methods (Pleus, 1999) at the downstream and upstream boundaries as close in time as possible (attach copies of completed Forms 7.0 and 7.1).

Resulting discharge measurements are compared to estimate the flow gain or loss within the reach. While walking through the thermal reach during the transect survey, record notes on obvious groundwater features such as significant springs or seeps or places where the stream appears to lose flow to the subsurface.

Transect Interval: Record the interval frequency used as the distance between transects in meters. The recommended guideline is to place transects at 25 meter (80 foot) intervals.

Dominant Land Use: Estimate and record the thermal reach dominant land use as either forestry; agriculture; rural; urban; mixed; or other. Dominance is defined as having a single land use practice cover an area equal to or greater than 70% of the total thermal reach area. If no land use is dominant, then record it as "Mixed."

Equipment

As field equipment is selected for conducting the thermal reach survey, document its type, size, condition, measurement accuracy, and pre-survey calibration dates as indicated. Mark the appropriate circle corresponding to whether equipment is in metric or English units. Document the type of wading gear used (wet; knee; hip; chest; dry; swim; etc.). Document any other measurement equipment used during the survey.

Reach Notes

Record thermal reach information related to factors affecting, or potentially affecting data quality and additional information related to parameters.

Sketch Map of Thermal Reach Site

This sketch map provides a view of the total thermal reach site and supplements both the station (Form 8.2) and the general site location (Form 8.0) sketch maps. Make a sketch map of the thermal reach area showing the location of the TI installation, right and left bank designations, flow direction, and easily identified thermal reach features such as tree groupings, meanders, and access trails (Figure 6). Keep the map as simple as possible and note which direction is north.

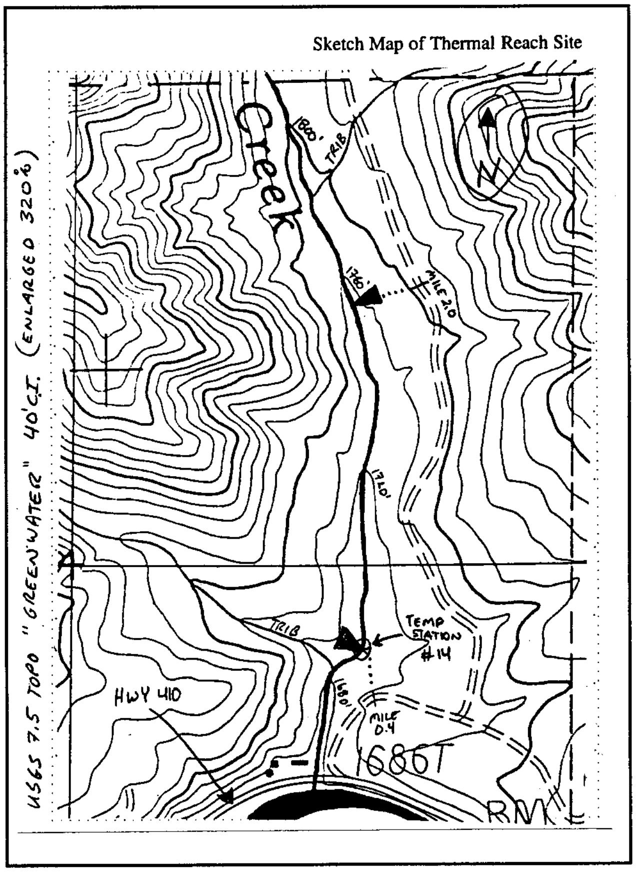


Figure 6. Detail of completed Form 8.3 "Sketch Map of Thermal Reach Site" section.

4.2.2 *Thermal Reach Characteristics Data Collection Procedure*

Data on thermal reach characteristics are primarily collected along transects placed at systematic intervals throughout the thermal reach (Figure 7). Characteristics of the thermal reach that influence stream temperature include cumulative distance, bankfull width and depth, wetted width and depth, canopy closure,

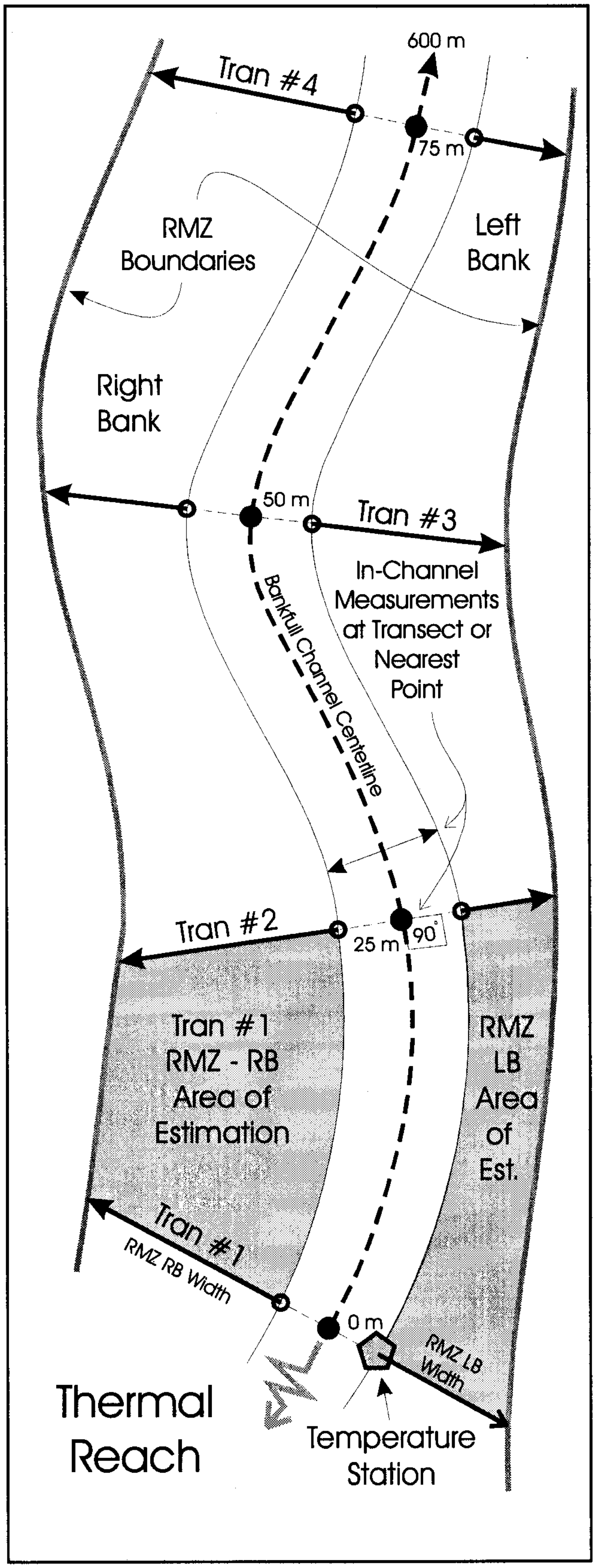


Figure 7. Data collection of thermal reach characteristics is conducted along 25 meter transects.

riparian management zone (RMZ) width and other information, stream gradient, and channel type. Measuring water temperature at each transect with a calibrated pocket thermometer and recording it in the field notes is a good technique for verifying that the temperature instrument is in a representative location of the thermal reach. Transect information is recorded on Form 8.3R. Mark the blank row after the last transect record "END OF SURVEY" for documentation.

Transect Number and Cumulative Distance

Establish and record the transect number in the *Tran #* column. Transects are laid out and numbered sequentially (1, 2, 3,...) beginning at the downstream temperature station and working to the upstream thermal reach boundary. Start by laying out the first transect at the temperature station. The transect forms a line that is perpendicular to the bankfull channel. An extended stadia road is useful to represent this line. Place weighted flags or tie flagging onto vegetation where the estimated line crosses each bank.

Measure and record the cumulative distance in the *Cum Dist* column from the temperature station to each subsequent transect. Cumulative distance is measured along the center line of the bankfull channel using the following technique. Anchor the end of the hip chain line to an object at the temperature station or last transect's midpoint in the bankfull channel. Proceed up the center of the bankfull channel, staying midway between the banks and following the curvature of the channel. Anchor the hip chain line to objects along the channel to maintain proper position, especially when going around channel meanders. Pieces of branches pushed into the gravel are useful as anchor points. Follow the center line within the limits of personal safety and accessibility.

The cumulative distance for a transect at the lower thermal reach boundary is "0." Each subsequent transect's cumulative distance reflects its total distance from the lower thermal reach boundary as measured along the center line of the bankfull channel. Cumulative distance is measured to the upstream thermal reach boundary.

The distance between the last transect and the upstream boundary transect must be greater than half an interval length. If the distance between the previous transect and the upper reach boundary is less than one and a half intervals (i.e., < 37.5 m for a 25 m interval frequency), the last transect location is the upper thermal reach boundary. If the distance is more than one and a half intervals (>/= 37.5 m), establish transects at both the 25 meter and upstream boundary locations.

Bankfull Width

Measure and record the bankfull width in the *BFW* column to the nearest 0.1 meter. Bankfull width is defined as the distance between the bankfull channel edges on each bank at or as near as possible to the transect interval and along a line that is perpendicular to the center line of the bankfull channel. Refer to the TFW Reference Point Survey (Pleus and Schuett-Hames, 1998b) for complete instructions. The following is a brief summary.

The first step is to identify the bankfull channel edges (BFCE). The TFW Monitoring Program uses a combination of three primary indicators developed by Dunne and Leopold (1978) to help identify the BFCE, including: 1) floodplain; 2) bank morphology and composition; and 3) vegetation. It is important to treat each BFCE placement as unique and weight all the indicators present equally. Also, it is useful to observe indicators along the length of the bank and look for similarities. In most situations, the confidence/default technique can be applied.

Start on the bank with the best BFCE indicators. Begin by observing indicators from within the bankfull channel toward its suspected edge and mark the point on the bank with a wire flag or stick where you no longer have 100 percent confidence in being within or below the BFCE elevation. Then, walk around outside of the channel to observe indicators from the floodplain or outside the bankfull channel towards the channel's suspected edge and similarly mark the point on the bank where you no longer have 100 percent confidence in being on the floodplain or above the BFCE elevation. Reassess the indicators and confidence levels and make any adjustments. The default BFCE boundary is the point in elevation midway between the other two markings. Follow the same procedure on the opposite bank and mark its BFCE. In situations where it is not possible to accurately identify the BFCE along the opposite bank, use a torpedo level to extend a level line horizontally across the channel from the bank with good indicators to determine the BFCE on the bank lacking indicators. This often occurs on the outside bank of a meander bend. Attach the zero end of a measuring tape at one BFCE and extending the tape across to the opposite BFCE. Stretch the tape tightly (no sag or deflections) and securely attach the measurement end of the measuring tape to the second anchor point. Do not remove the bankfull width tape until bankfull depth and canopy closure have been measured.

Multiple channels require separate bankfull width measurements along the same transect orientation. This includes wetted or dry channels that are connected to the primary low flow channel by ingress and/or egress access, but separated by gravel bars or islands that are higher than bankfull height. Complete all measurements and documentation at the primary channel before going to an adjacent or side channel. Each channel measurement is recorded on separate Form 8.3R rows, but associated with the same transect by using a letter code (e.g., 14a, 14b, l4c, etc.). Multiple channels require additional calculations before entry into the database that are best documented by leaving a blank data collection row after recording all channel information. Using the example above, this row would be identified as "MC- 14".

Bankfull Depth

Measure and record the bankfull depth measurement in tile BFD column to the nearest 0.01 meter. Bankfull depth is the distance from the channel bed to the top of the bankfull channel, represented by the elevation of the tape stretched between the BFCEs (Figure 8). Water depth or the absence of water at the time of the survey does not affect this measurement. Refer to the TFW Reference Point Survey for complete instructions. The following is a brief summary.

The BFD 10% cell method divides the bankfull width into 10 evenly spaced cells or sections. Depth measurements are then taken at stations in the center of each cell. To determine station intervals along the bankfull width tape:

✔ Calculate the cell interval by dividing the bank-full width by 10 (move the decimal place left one) and record the result to the nearest 0.01 meter in the small box to the left of the *Tape Station* caption.

✔ Calculate the first tape station by dividing the cell interval in half and adding this number to the BFW tape reading at the tape's zero end. Record the tape

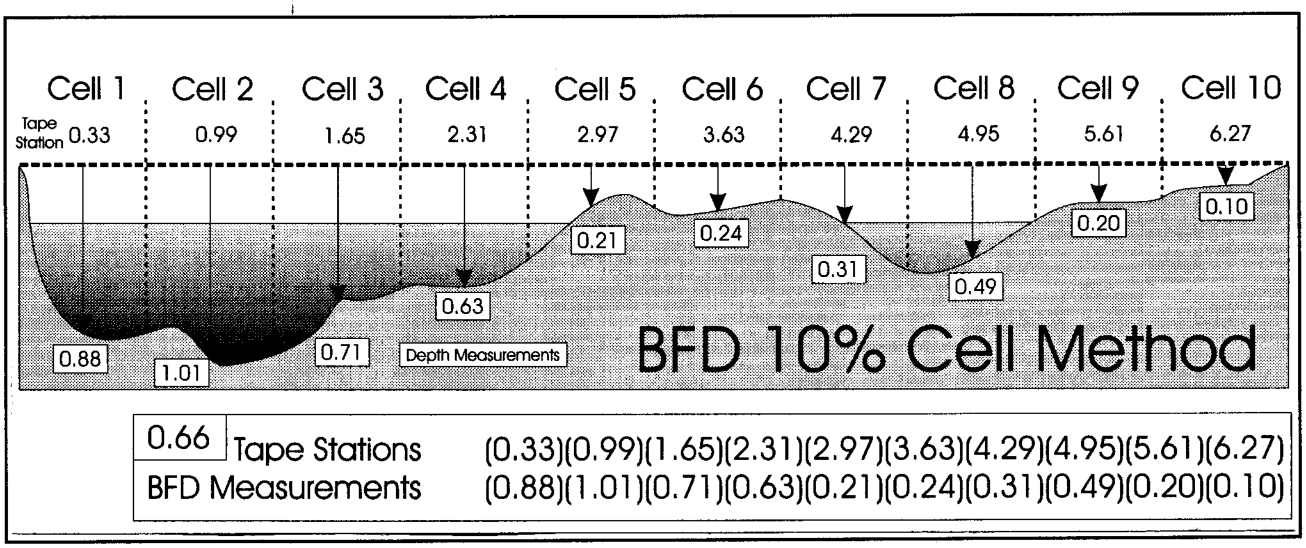


Figure 8. Bankfull depth 10% cell method with calculated tape station distances and depth measurements taken at each tape station recorded in brackets on Form 8.3R.

station interval to the nearest 0.01 meter in first bracket of the *Tape Station* set of brackets for that transect.

✔ Calculate the subsequent nine intervals by adding one full interval distance to the previous adjacent station along the tape. Record the tape station intervals to the nearest 0.01 meter in their proper sequence in the *Tape Station* set of brackets for that transect.

Bankfull depths are measured plumb (vertically level) from each tape station to the channel bed and recorded in the *BFD Measurements* brackets below the corresponding *Tape Station* bracket. When all bankfull depth measurements have been taken, calculate the mean bankfull depth by adding all the BFD measurements together and then dividing the sum by 10 (the number of depth measurements taken). Do not remove the bankfull width tape until canopy closure has been measured and reference photos have been taken.

Wetted Width

Measure and record the wetted width in the *WW* column to the nearest 0.1 meter. Wetted width is defined as the distance between the wetted channel edges on each bank along the transect (BFW) line. Wetted width can be measured by using a second measuring tape or rod or calculated by subtracting BFW tape distances corresponding to wetted channel edge locations.

Wetted Depth

Measure and record the wetted depth measurement in the WD column to the nearest 0.01 meter using the 10% cell method as described for measuring bankfull depth. Wetted depth is the distance from the channel bed to the top of the water surface along the transect line.

Canopy Closure

Measure and record four canopy closure measurements for each transect in the *Canopy Closure Up, LB, Dn, RB* columns to the nearest point. Calculate and record the percent canopy closure in the *Canopy Closure %* column to the nearest percent. In situations with multiple wetted channels, measure and record canopy closure along the primary low-flow channel only (Sullivan et al., 1990). Refer to the TFW Reference Point Survey for complete instructions. The following is a brief summary.

Begin by finding the center of the primary low flow (PLF) or main channel (> 50 percent of wetted width) along the tape used for the bankfull width and depth measurements. Position the densiometer with its center gridline pointed in the up-channel direction (*Up*) at an angle perpendicular to the bankfull width tape. Using a tripod, stabilize the instrument by adjusting the legs for uneven channel beds. Adjust the densiometer's height to a position as close to the water surface as possible in relation to mechanical and measurement accuracy limitations. Level it using the densiometer's bubble level. With one eye closed, look down on the surface of the densiometer mirror and adjust your head until the reflection of the top of your forehead (not bangs, top of hair or hat) just touches the outside of the grid and your sighting eye is directly in line with the grid centerline (Figure 9). While maintaining this position, count the number of sampling points that have canopy closure factors covering more than 50 percent of the dot. Use of a mechanical tally counter simplifies this procedure and provides more consistent measurements.

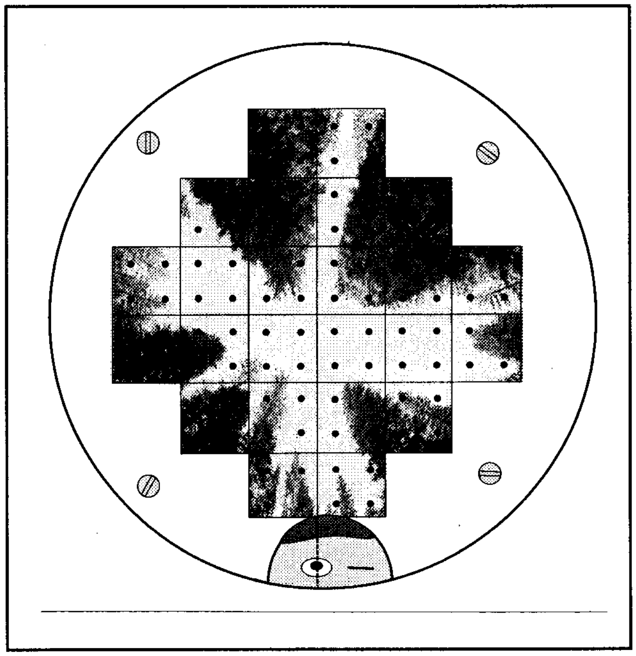


Figure 9. Example of using the convex spherial densiometer with proper eye position along the grid centerline.

Using the densiometer as the axis of rotation, repeat this procedure for Left Bank (*LB* - grid centerline parallel to tape), Downstream (*Dn* - grid centerline perpendicular to tape), and Right Bank (*RB* - grid centerline parallel to tape) directions. The maximum count is 96 and the minimum count is 0. The percent canopy closure is then calculated in the field by adding together the four directional closure sample point totals, dividing the sum by four, and multiplying the result by 1.04. Round the result to the nearest percent.

Riparian Management Zone

The riparian management zone (RMZ) is defined as a band of riparian vegetation along the stream corridor that is managed differently than the adjacent upland areas. Vegetation in the RMZ is typically older and may have a different species composition than the adjacent areas managed for timber harvest, agriculture, or other land uses. The edge of the RMZ can be identified by tree markings, harvest boundary line, or breaks in seral stage from past harvests. The RMZ area of estimation is bounded by the bankfull channel edge, the RMZ edge, and the interval distance between the last downstream and next upstream thermal reach transect.

RMZ Width: At each transect, measure the right and left bank riparian management zone (RMZ) widths and record the results in the *RMZ RB* and *RMZ LB* columns on the *Width* row to the nearest 1.0 meter. RMZ width is measured from each respective bankfull channel edge to the edge of that bank's RMZ along a line perpendicular to the bankfull channel centerline and intersecting the transect interval. The maximum RMZ width is 90 meters (300 feet) and this should be recorded in situations where the RMZ edge extends farther, or cannot be determined in undisturbed areas.

Cover: Estimate and record the dominant *RMZ RB* and *RMZ LB* overstory in the *Cover* row as either conifer (C), hardwood (H), mixed (M), or other (O) (WFPB, 1996). Dominance is defined as having a either single category overstory cover equal to or greater than 70 percent of the total RMZ estimation area as defined above. Mixed dominance is where the combined conifer and hardwood overstory meet the 70 percent cover, but neither individual type is over the criteria. Other dominance is where the combined conifer and hardwood overstory does not meet the 70 percent cover criteria. Describe the condition in the field notes.

Size: Estimate and record the *RMZ RB* and *RMZ LB* average tree diameter size class in the *Size* row as either small (S), medium (M), or large (L) (WFPB, 1996). Average is defined as the estimated combined diameters divided by the total number of trees. Diameter classes are defined as: small are trees less than 30 centimeters (12 inches) diameter at breast height (DBH); medium are trees equal to or greater than 30 cm and less than 50 cm (20 inches) DBH; and large are trees equal to or greater than 50 cm DBH.

Density: Estimate and record the *RMZ RB* and *RMZ LB* density class in the *Density* row as either sparse (S) or dense (D)(WFPB, 1996). Estimating density class for western Washington streams is as follows:

"Density is sparse if more than 1/3 of the ground is exposed. Otherwise it is dense." Estimating density class for eastern Washington streams is as follows: "Density is sparse if more than ½ of the ground is exposed. Otherwise it is dense."

Windthrow: Estimate and record the presence of *RMZ RB* and *RMZ LB* windthrow in the *Wind* row as either yes (Y) or no (N). A "yes" windthrow designation is defined as equal to or greater than 10% of the conifer/hardwood overstory having recently fallen (within last year) due to wind. For example, this would describe an RMZ estimation area of 30 trees where three or more have recently fallen.

Stream Gradient

Measure the gradient between the previous transect and the present transect and record it in the *Grad* column to the nearest percent. Record the gradient as a positive number. Gradient is defined as the ratio of rise over run, or the elevation gain between the transects divided by the distance between them. Refer to Sullivan et al. (1990) or Harrelson et al. (1994) for stream gradient measurement methods. The first transect will not have a gradient recorded. Using clinometers is not recommend due to accuracy concerns.

Channel Type

Estimate the primary channel type between the previous transect and the present transect and record it in the *Chan Type* column as a two or three letter character code using the Montgomery and Buffington (1993) classification system. Document whether there is substantial modification by aggregation, debris flows, beaver activity or other influences in the Reach Notes section.

5. Post-Survey Documentation

After completion of the field portion of the Stream Temperature Survey, data loggers need to be downloaded, temperature instruments undergo post-survey calibration, field forms are organized, supplemental information and calculations are completed, and all forms and information are error checked before the data is entered into the database. The objective of this section is to organize the data to ensure that this survey can be repeated the same way in the future by different crews.

5.1 Download Data Logger Files

Download temperature data per manufacturer instructions or export into an Excel or Lotus spreadsheet. Save one working copy and one unedited copy of the data. The unedited/unaltered copy of each original data file should be saved on a disk or backup drive for legal challenge purposes and in case of working copy loss.

5.2 Post-Survey Calibration

A post-survey calibration check is done to determine if the temperature instruments accurately and consistently recorded data from the installation to removal period. Follow the pre-survey calibration procedures described in the Pre-Survey Preparation section. Record the results in the Post sections on either Form 8.1L or 8.1M. Pre- and post-survey calibration data boxes have been placed on the same page for easy reference. When the post-survey calibration procedure has been completed and results finalized, use this information to determine if the data is acceptable, or needs to be edited, adjusted, or discarded. Discarding or rejecting all temperature data may not be necessary where post-survey calibration results in a mean difference or Max pin difference greater than 2 degrees Celsius.

5.3 Edit and Adjust Temperature Data Files

Information gathered at periodic station checks on Forms 8.2L and 8.2M can be used to detect data logger and Max/Min thermometer problems and when they started. The best way to detect anomalous data logger problems is to prepare an X-Y graph of the time and temperature data. Air temperature data collected at the same station is also valuable for checking and verifying problems. Anomalous data are deleted from the files before they are imported into the TFW database. Good documentation is required to explain the reasons for editing any data. Likewise, if any calibration adjustments are made to the data, the basis for the adjustments must be well documented.

Data Loggers

Use the working copy to edit the temperature data. The three basic editing functions are: 1) delete all temperature data recorded before installation and after removal dates and times; 2) check the data for anomalies such as drifting and spiking problems; and 3) adjust temperature data based on calibration results.

Data loggers that are launched before installation at the temperature station are collecting non-survey data related to air temperatures and/or equilibrium transitions. A general rule would be to delete any data recorded prior to or up to one hour after the installation time as stated on Form 8.2. Data loggers that were set for delayed launch after installation usually don't need this editing. Data loggers are typically downloaded at various times after removal from the temperature station and therefore are also collecting data is not part of the survey. A general rule would be to delete any data recorded up to one hour before and anytime after the removal time as stated on Form 8.2.

Check the remaining data for anomalies such as exposure, drift, and spike problems. Remove any anomalies that cannot be explained or supported by comparisons to paired data sets (upstream/ downstream and air temperature stations) and periodic field checks. Exposure problems are where the water level fell below the height of the temperature instrument and began recording air temperatures. Depending upon the hydrologic regime of the stream, this could cover one or more intervals of time. Most drifting problems are caused by changes in the water column at the temperature station such as flow level or disturbance. That is, the instrument is accurately recording ambient conditions, but it may no longer be positioned in an area of adequate water mixing. Drifting problems caused by instrument failure are often detected in the post-survey calibration process where mean differences were greater than 2 degrees Celsius. Spiking problems are most often caused by sunlight hitting a data logger and causing it to record higher temperatures due to direct heat transfer and absorption by radiation.

Adjustments to the temperature data can be made if the pre- and post-survey calibration results showed a consistent bias from the reference thermometer. The simplest procedure is to use a spreadsheet calculation function to convert the temperature column data.

Max/Min Thermometers

The two basic editing functions are 1) checking the data for anomalies such as drifting and spiking problems, and 2) adjust temperature data based on calibration results. Anomalies are more difficult to detect as there is only one temperature point available. The use of information gathered during periodic station checks and cross-checking with air temperature instrument data becomes more important. Adjustments to the temperature data can be made if the pre- and post-survey calibration results showed a consistent bias from the reference thermometer. This can be done as each temperature measurement is entered into the database entry form, or using a spreadsheet to convert before database entry.

5.4 Finalizing Field Forms

Organize the forms and check for missing sheets. Systematically check each TEMP Survey form for completeness. All blanks and boxes should contain information or a "/" to designate that no information is available or needed. The following list provides guidance on some common tasks.

✔ The page number should be filled in as used during the survey (e.g., Page 1 of _, Page 2 of _, Page 3 of __, etc.). Forms that have been copied on both side of one sheet of paper will count as two separate pages.

✔ Page numbering is related to form type. Count the number of total pages for each form type.

✔ The total number of pages for each type of form is filled in at the end of the survey (e.g., Page 1 of 6, Page 2 of 6, Page 3 of 6, etc.).

✔ Organize the field forms by type and then by page number for easy reference. It is common to have different totals for each type.

✔ Complete any missing information and calculations.

5.5 Error Checking

Error checking of field forms is a very important task and sufficient time should be taken to complete it. It is best done during or immediately after data collection because it becomes more difficult to reconcile discrepancies and track down correct information as time passes. Contact the TFW-MP for assistance in determining how to handle missing data fields.

Review all field forms and material compiled during the Stream Temperature Survey. Have a second person look them over for completeness, legibility and errors. Every page of every form requires error checking for legibility, complete and consistent header information, obvious measurement and transcription errors, and calculation errors. Work systematically through each section and when completed, put your initials and date in the *Error Checked by* box at the bottom of each page. If the person error checking the data is not a crew member, their full name and task should be recorded in the *Survey Notes* section of Form 8.0. When all field forms relating to a temperature station have been error checked, record the initials of the responsible crew and date completed.

6. Data Management

The TFW Monitoring Program offers data management services to help cooperators quickly analyze data collected with the program methods and to produce standard monitoring reports. The heart of the service is a database system housed at the Northwest Indian Fisheries Commission. This database calculates parameters, produces reports and archives electronic versions of the data. The database is also an important archive of monitoring data that can be used for developing study designs and identifying control or reference sites. This section describes the process for data preparation, data processing and archiving, and data analysis.

6.1 Data Preparation

The TFW database is designed to accept temperature data collected from different types of instruments. The first step is to import the data into the database. Temperature survey header information, Max/Min temperature data, and thermal reach data are entered by hand, using a spreadsheet or database entry system available from the TFW Monitoring Program. Temperature data from data loggers must be downloaded into a file using software provided by the data logger manufacturer. Both hand-entered and data logger generated files should be error-checked for accuracy and forwarded to the TFW Monitoring Program for entry into the database. Before data entry can occur for the Stream Temperature Survey, some preparation must be done. The following materials are needed:

✔ completed and error-checked Forms 8.0, 8.2M, 8.3, and 8.3R as needed for each segment;

✔ a data entry system;

✔ a set of data entry system instructions and an "Ambsys" data dictionary; and

✔ a copy of completed Stream Segment Identification Form 1.0

Before the data entry process can begin, an entry system must be selected. Choose a data entry system from the list below and request a free copy and user's manual from the TFW Monitoring Program. The database has three entry system options for survey data. These are:

- Microsoft Excel 4.0 pre-formatted spreadsheets;
- Lotus 1-2-3 (vers. 3) pre-formatted spreadsheets; and
- Microsoft Access 7.0 pre-formatted entry forms

Select a spreadsheet format if your thermal reach characteristic data requires conversion from English to metric units. Read the instructions for the data entry system and the Ambsys data dictionary, noting the field types and data constraints (what type of data can be entered into each field). Refer to Appendix D for examples of each Excel pre-formatted spreadsheet.

6.2 Data Processing, Products and Archiving

Open the section of the entry system pertaining to the Stream Temperature Survey on your computer. Following the entry system instructions, enter the data from Forms 8.0, 8.2M, 8.3, and 8.3R as directed. After the data has been entered and the session saved, error check the data entry. The most efficient technique for this time-consuming task is to have one person read the data off the screen and another check it with the original field form. Save the file a final time once the data has been error checked. When completed, record the initials of the responsible crew and date on Form 8.0.

Data can be sent to the TFW Monitoring Program using several different methods. Copies of all survey field forms and other documentation are required for archiving and can be hand delivered, mailed, or faxed to the program. An original or copy of a USGS topographic map is also required and can be hand delivered, mailed, or faxed. Maps must have upstream and downstream segment boundaries marked along the stream. If a photocopy of the map is used, make sure the township, range, section, contour intervals, map name, and publishing date are identified. The electronic versions of the data can be sent via e-mail, CD, or on a floppy disk. After the program receives the electronic files, the data is imported into the database by a TFW-MP staff person.

Safe and efficient archiving is also provided by the TFW Monitoring Program to save data and survey reach locations for future use. The data generated by individual cooperators is archived electronically in the database system. Hard copies of the field forms, topographic maps and supplemental information are archived at the TFW-MP facility. Access to data can be limited at the request of the cooperator contributing the data to the database. Call for information on the data access policy.

6.3 Data Analysis

Data collected during the Stream Temperature Survey is used to generate summary reports that present analyzed results derived from calculations done by the database. Analysis is divided into water, air, and thermal reach summary reports. Each report covers data collected at one temperature station or thermal reach. The following is a brief description of the data analysis reports.

6.3.1 Temperature Survey Water and Air Summary Reports

Water and Air temperature reports are available in project, daily, weekly and monthly formats. All report headers contain similar information including stream name, WRIA number, survey date span, segment and sub-segment numbers, temperature station number, station location, midpoint elevation (thermal reach), station elevation, thermal reach length, downstream and upstream discharges, survey length, and survey leader and their affiliation. Summary reports also provide information on the temperature instrument used to collect the data including make, model, identification number, and pre/post calibration dates. Table 1 provides a matrix of TEMP Survey water and air temperature summary reports by type and parameter. Some calculations may not be possible for max/min data.

Table 1. Matrix of Stream Temperature Survey Water and Air Summary Reports by type and parameter.

Parameters	Temperature Survey **Water** Summary Reports				Temperature Survey **Air** Summary Reports			
	Project	Daily	Weekly	Monthly	Project	Daily	Weekly	Monthly
# days w/readings	X		X	X	X		X	X
# readings per date		X				X		
Max temp	X	X	X	X	X	X	X	X
Mean daily Max	X		X	X	X		X	X
Min temp	X	X	X	X	X	X	X	X
Mean daily Min	X		X	X	X		X	X
Mean temp	X	X	X	X	X	X	X	X
Daily temp change		X				X		
Mean daily temp change	X		X	X	X		X	X
Max daily temp change	X		X	X	X		X	X
Exceed WQS?	X	X	X	X				
Total days exceed WQS	X		X	X				
Total hours exceed WQS	X	X	X	X				

6.3.2 Thermal Reach Characteristics Summary Report

The Thermal Reach Characteristics Summary Report header contains similar information to the water and air reports including stream name, WRIA number, survey date span, segment and sub-segment numbers, temperature station number, station location, midpoint elevation (thermal reach), station elevation, thermal reach length, downstream and upstream discharges, survey length, and survey leader and their affiliation. This report also includes the reach's dominant channel type, mean stream (reach) gradient, and the mean, maximum, and minimum values for bankfull width, bankfull depth, wetted width, wetted depth, right bank riparian management zone width, left bank riparian management zone width, and percent canopy closure.

7. References

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8. Appendixes

Appendix A
Form 8.0, 8.1L, 8.1M, 8.2, 8.2L, 8.2M, 8.3, and 8.3R Copy Masters

Appendix B
Examples of Completed Field Forms

Appendix C
Standard Field and Vehicle Gear Checklist Copy Master

Appendix D
Data Management Examples

Appendix E
Washington State Water Quality Standards Classification List

Appendix F
Sullivan et al., 1990: Stream Gradient Measurement Method

Appendix G
Stream Temperature Regions of Washington Map

Appendix A

Form 8.0, 8.1L, 8.1M, 8.2, 8.2L, 8.2M, 8.3, and 8.3R Copy Masters

(Keep original copy master with manual)

Stream Name

TEMPERATURE SURVEY — HEADER INFORMATION — FORM 8.0

WRIA # ___ ___ . ___ ___ ___ ___   Unlisted Trib ___ ___ ___ ◯ RB ◯ LB   **Segment #** ________   ______ Sub-Segment Code   **Date** _____/_____/________

Study Design Information

Temperature Station # [ ]

Begin Survey Date ___/___/_____ (Installation)

End Survey Date ___/___/_____ (Removal)

Temperature Station Location

WRIA River Mile ________ ◯ M

Station Elevation ________ ◯ F

Township T________

Range R________

Section ________

Qtr of Qtr ___ of ___

Circle one

Water Quality Class **A AA B**

Temperature Region **W E**

Forms Used:

- ◯ Data Logger Calibration Form 8.1L
- ◯ Max/Min Calibration Form 8.1M
- ◯ Station Documentation Form 8.2
- ◯ Data Logger Field Check Form 8.2L
- ◯ Max/Min Data Form 8.2M
- ◯ Thermal Reach Header Form 8.3
- ◯ Thermal Reach Data Form 8.3R
- ◯ Other ______________________

____

____

◯ CELSIUS *Water* ◯ FAHRENHEIT

Data Logger/Thermometer

Make ______________

Model ______________

TI/PROBE ID # __________

Pre-Calib ___/___/______

Post-Calib ___/___/______

◯ CELSIUS *Air* ◯ FAHRENHEIT

Data Logger/Thermometer

Make ______________

Model ______________

TI/PROBE ID # __________

Pre-Calib ___/___/______

Post-Calib ___/___/______

Survey Crew

Name	*Affiliation*	
______________	______________	(Lead)
______________	______________	(Rec.)
______________	______________	

Crew Lead: Year of most recent TEMP   Training _____   QA Review _____

Survey Notes

____

____

____

Sketch Map of Temperature Station Site

(1:24,000 topo map scale)

USGS 7.5 min Topographic Map Name

Form 8.0

Error Checked by: _____ Date: ___/___/___

All Field Forms

Error Checked by: _____ Date: ___/___/___

All Data Entry

Error Checked by: _____ Date: ___/___/___

TFW Monitoring Program

Stream Name

Crew Lead ____
Recorder(s) ____ ____

Page ___ of ___

TEMPERATURE SURVEY

DATA LOGGER CALIBRATION

FORM 8.1L

WRIA # __ __ . __ __ __ __ Unlisted Trib ____ ◯ RB ◯ LB

Segment # ______ ____ Sub-Segment Code

Station # ______

TI/Probe ID# [ ]

Data Logger ◯ CELSIUS ◯ FAHRENHEIT
Make ______
Model ______
Manu. Accuracy (+/-) ______ °

Ref. Therm. ◯ CELSIUS ◯ FAHRENHEIT
Make ______
Model ______
Manu. Accuracy (+/-) ______ °

TI/Probe ID# [ ]

Data Logger ◯ CELSIUS ◯ FAHRENHEIT
Make ______
Model ______
Manu. Accuracy (+/-) ______ °

Ref. Therm. ◯ CELSIUS ◯ FAHRENHEIT
Make ______
Model ______
Manu. Accuracy (+/-) ______ °

PRE Date __/__/____ Bath ◯ Roomtemp ◯ Ice ◯ Sand ◯ Span				**POST** Date __/__/____ Bath ◯ Roomtemp ◯ Ice ◯ Sand ◯ Span				**PRE** Date __/__/____ Bath ◯ Roomtemp ◯ Ice ◯ Sand ◯ Span				**POST** Date __/__/____ Bath ◯ Roomtemp ◯ Ice ◯ Sand ◯ Span			
Time	**Ref Therm°**	**TI°**	**Diff°**	**Time**	**Ref Therm°**	**TI°**	**Diff°**	**Time**	**Ref Therm°**	**TI°**	**Diff°**	**Time**	**Ref Therm°**	**TI°**	**Diff°**
◯ Accept ◯ Reject		Mean Diff ____		◯ Accept ◯ Edit/Reject		Mean Diff ____		◯ Accept ◯ Reject		Mean Diff ____		◯ Accept ◯ Edit/Reject		Mean Diff ____	

TFW Monitoring Program

Stream Name

Crew Lead ____
Recorder(s) ____ ____

Page ___ of ___

TEMPERATURE SURVEY — MAX/MIN CALIBRATION — FORM 8.1M

WRIA # ___ ___ . ___ ___ ___ ___   Unlisted Trib ___ ◯ RB ◯ LB   **Segment #** ______   ______ Sub-Segment Code   **Station #** ________

TI/Probe ID#

Max/Min Therm. ◯ CELSIUS ◯ FAHRENHEIT
Make ____________
Model ____________
Manu. Accuracy (+/-) ______ °

Ref. Therm. ◯ CELSIUS ◯ FAHRENHEIT
Make ____________
Model ____________
Manu. Accuracy (+/-) ______ °

PRE

Date ___/___/_____

Bath	Time	Ref Therm °	Thermometer Max °	Thermometer Min °	Diff Max °	Diff Min °	Pin Max °	Pin Min °
# 1								
# 2								
# 3								

Max Pin Difference _____ °
Min Pin Difference _____ °

◯ Accept
◯ Reject

POST

Date ___/___/_____

Bath	Time	Ref Therm °	Thermometer Max °	Thermometer Min °	Diff Max °	Diff Min °	Pin Max °	Pin Min °
# 1								
# 2								
# 3								

Max Pin Difference _____ °
Min Pin Difference _____ °

◯ Accept
◯ Edit/Reject

TI/Probe ID#

Max/Min Therm. ◯ CELSIUS ◯ FAHRENHEIT
Make ____________
Model ____________
Manu. Accuracy (+/-) ______ °

Ref. Therm. ◯ CELSIUS ◯ FAHRENHEIT
Make ____________
Model ____________
Manu. Accuracy (+/-) ______ °

PRE

Date ___/___/_____

Bath	Time	Ref Therm °	Thermometer Max °	Thermometer Min °	Diff Max °	Diff Min °	Pin Max °	Pin Min °
# 1								
# 2								
# 3								

Max Pin Difference _____ °
Min Pin Difference _____ °

◯ Accept
◯ Reject

POST

Date ___/___/_____

Bath	Time	Ref Therm °	Thermometer Max °	Thermometer Min °	Diff Max °	Diff Min °	Pin Max °	Pin Min °
# 1								
# 2								
# 3								

Max Pin Difference _____ °
Min Pin Difference _____ °

◯ Accept
◯ Edit/Reject

Stream Name

Crew Lead ____
Recorder(s) ____ ____

TEMPERATURE SURVEY

STATION DOCUMENTATION

FORM 8.2

WRIA # __ __ . __ __ __ __   Unlisted Trib __ __ __ ○ RB ○ LB   **Segment #** ______   ____ Sub-Segment Code   **Station #** ________

Water
TI/Probe ID # [ ]

Launch Date ___/___/______
Launch Time __ __ __ __
Interval Frequency ________
Reading Mode
○ Point
○ Max
○ Mean
○ Other ______
Download Date ___/___/______
Download Time __ __ __ __

Air
TI/Probe ID # [ ]

Launch Date ___/___/______
Launch Time __ __ __ __
Interval Frequency ________
Reading Mode
○ Point
○ Max
○ Mean
○ Other ______
Download Date ___/___/______
Download Time __ __ __ __

TI Installation

Begin Survey Date & Time
__/__/____   __ __ __ __

Site Info
Bankfull Width ______ M - F
Wetted Width ______
Canopy Closure ______ %
__ __ __ __
UP LB DN RB

Water Info
Temperature (pocket thermometer) ______ °C - F
Depth @ TI ______
TI Height (above channel bed) ______

Air Info
Temperature (pocket thermometer) ______ °
TI Height (above water surface) ______
TI Distance (from BFCE)

Weather Conditions ____________
____

Photographs
Roll # ______   Frame # & Info
____
____
____
____
____
____
____

TI Removal

End Survey Date & Time
__/__/____   __ __ __ __

Sketch Map of Installation Site and Notes

ERROR CHECKED by: ____ Date: ___/___/___

TFW Monitoring Program

Stream Name

Crew Lead ____
Recorder(s) ____ ____

Page ___ of ___

TEMPERATURE SURVEY

DATA LOGGER FIELD CHECK

FORM 8.2L

WRIA # __ __ . __ __ __ __   Unlisted Trib ____ ○ RB ○ LB   **Segment #** ______ ____ Sub-Segment Code   **Station #** ________

Water **TI/Probe ID #**
Air **TI/Probe ID #**

Measurement Units
○ CELSIUS ○ FAHRENHEIT
○ METERS ○ FEET

Station Check #								
Date								
Time								
Site								
Wetted Width								
Water								
Temperature @ TI (pocket therm.)								
Depth @ TI								
TI Height (above channel bed)								
Download (Y/N)								
Air								
Temperature @ TI (pocket therm.)								
TI Height (above water surface)								
Download (Y/N)								
Weather Conditions								
Notes								

Stream Name ____

Crew Lead ____
Recorder(s) ____ ____

TEMPERATURE SURVEY

MAX/MIN DATA

FORM 8.2M

WRIA # ___ ___ . ___ ___ ___ ___ ___

Unlisted Trib ___ ___ ___ ◯ RB ◯ LB

Segment # ________ ______ Sub-Segment Code

Station # __________

Water **TI/Probe ID #** ____
Air **TI/Probe ID #** ____

Measurement Units
◯ CELSIUS ◯ FAHRENHEIT
◯ METERS ◯ FEET

Station Check #								
Date								
Time								
Site								
Wetted Width								
Water								
Max Temp Pin								
Min Temp Pin								
TI Temp								
Temperature @ TI (pocket therm.)								
Depth @ TI								
TI Height (above channel bed)								
Air								
Max Temp Pin								
Min Temp Pin								
TI Temp								
Temperature @ TI (pocket therm.)								
TI Height (above water surface)								
Weather Conditions								
Notes								

ERROR CHECKED by: ____ Date: ___/___/___

TFW Monitoring Program

Stream Name

Crew Lead ____
Recorder(s) ____ ____ Page ___ of ___

TEMPERATURE SURVEY

THERMAL REACH SURVEY DESCRIPTION

FORM 8.3

WRIA # __ __ . __ __ __ __   Unlisted Trib __ __ __ __ ○ RB ○ LB   **Segment #** ______   ______ Sub-Segment Code   **Station #** ______

Thermal Reach Information

Water **TI/Probe ID #**
Air **TI/Probe ID #**

Begin Survey Date ___/___/_____

Thermal Reach Length ________ M - F

Mid Reach Elevation ________ M - F

Groundwater Inflow Rate
Upstream __ __.__ __
Downstream __ __.__ __   CMS - CFS

Transect Interval ________ M - F

Dominant Land Use ________

Reach Notes

Sketch Map of Thermal Reach Site

Equipment ○ Meters ○ Feet	Type	Size	Cond	Accu-racy	Pre-Calibrated	Post-Calibrated

ERROR CHECKED by: ____ Date: ___/___/___

Stream Name

Crew Lead ____
Recorder(s) ____ ____

TEMPERATURE SURVEY

○ METERS
○ FEET

THERMAL REACH CHARACTERISTICS

FORM 8.3R

WRIA # ___ ___ . ___ ___ ___ ___ Unlisted Trib ○ RB ○ LB ____ **Segment #** ______ ____ Sub-Segment Code **Date** ___/___/___

Tran #	Cum Dist	BFW	BFD	WW	WD	Canopy Closure Up	LB	Dn	RB	%	RMZ	RB	LB	Grad	Chan Type	**Begin Survey Date** ___/___/___ **Station #** ______
											Width					
Tape Stations ( )( )( )( )( )( )( )( )( )( )											Cover			Field Notes		
BFD Measurements ( )( )( )( )( )( )( )( )( )( )											Size					
Tape Stations ( )( )( )( )( )( )( )( )( )( )											Density					
WD Measurements ( )( )( )( )( )( )( )( )( )( )											Wind					
											Width					
Tape Stations ( )( )( )( )( )( )( )( )( )( )											Cover			Field Notes		
BFD Measurements ( )( )( )( )( )( )( )( )( )( )											Size					
Tape Stations ( )( )( )( )( )( )( )( )( )( )											Density					
WD Measurements ( )( )( )( )( )( )( )( )( )( )											Wind					
											Width					
Tape Stations ( )( )( )( )( )( )( )( )( )( )											Cover			Field Notes		
BFD Measurements ( )( )( )( )( )( )( )( )( )( )											Size					
Tape Stations ( )( )( )( )( )( )( )( )( )( )											Density					
WD Measurements ( )( )( )( )( )( )( )( )( )( )											Wind					
											Width					
Tape Stations ( )( )( )( )( )( )( )( )( )( )											Cover			Field Notes		
BFD Measurements ( )( )( )( )( )( )( )( )( )( )											Size					
Tape Stations ( )( )( )( )( )( )( )( )( )( )											Density					
WD Measurements ( )( )( )( )( )( )( )( )( )( )											Wind					

ERROR CHECKED by: ____ Date: ___/___/___

Appendix B

Completed Examples of Forms 8.0, 8.1L, 8.1M, 8.2, 8.2L, 8.2M, 8.3, and 8.3R Copy Masters

Stream Name SLIPPERY CREEK

TEMPERATURE SURVEY — HEADER INFORMATION — FORM 8.0

WRIA # 10.0118 Unlisted Trib 000 ○ RB ○ LB Segment # 1 ∅ Sub-Segment Code Date 7/10/97

Study Design Information

Temperature Station # 14

Begin Survey Date 7/11/97 (Installation)

End Survey Date 9/29/97 (Removal)

Temperature Station Location

WRIA River Mile 0.1

Station Elevation 1680 ○ M ● F

Township T 19N

Range R 9E

Section 4

Qtr of Qtr NE of SE

Water Quality Class (Circle one) A (AA) B

Temperature Region (W) E

Forms Used:

- ● Data Logger Calibration Form 8.1L
- ○ Max/Min Calibration Form 8.1M
- ● Station Documentation Form 8.2
- ○ Data Logger Field Check Form 8.2L
- ○ Max/Min Data Form 8.2M
- ● Thermal Reach Header Form 8.3
- ● Thermal Reach Data Form 8.3R
- ● Other(2) WSOM Forms 7.0 & 7.1

Water

● CELSIUS ○ FAHRENHEIT

Data Logger/Thermometer

Make ONSET

Model HOBO-TEMP

TI/PROBE ID # 18543 #17

Pre-Calib 6/25/97

Post-Calib 10/3/97

Air

○ CELSIUS ○ FAHRENHEIT

Data Logger/Thermometer

Make ONSET

Model HOBO TEMP

TI/PROBE ID # 18547 #19

Pre-Calib 6/25/97

Post-Calib 10/3/97

Survey Crew

Name	Affiliation
ALLEN PLEUS	TFW MONITORING PROGRAM (Lead)
DEVIN SMITH	" (Rec.)

Crew Lead: Year of most recent TEMP Training '97 QA Review '97

Survey Notes

▶ SITE JUST UPSTREAM FROM HWY 410 BRIDGE JUST BELOW TOWN OF GREENWATER AND CONFLUENCE OF GREENWATER/WHITE RIVERS (RB)

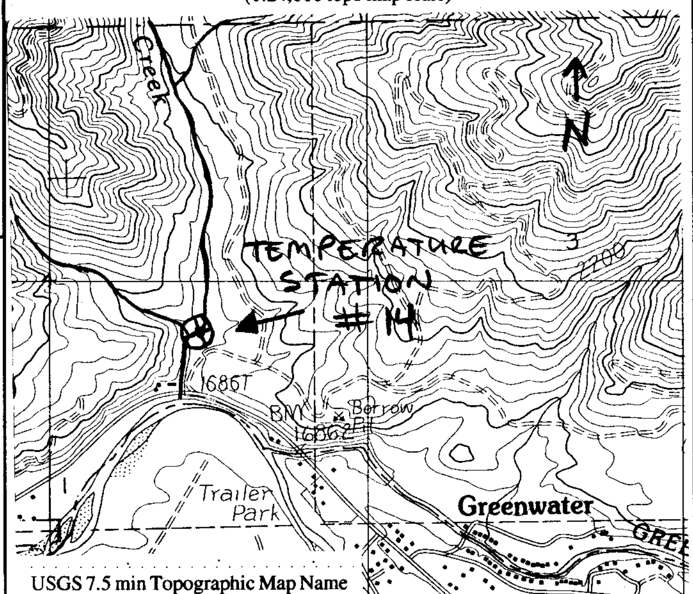
▶ USE GRAVEL ACCESS ROAD APPROX. 0.4 MILES FROM 410

▶ PRE-POST CALIBRATION W/ CERT. REF THERM VWR 61099-035 SERIAL # 207459 CERT. REF # 80954617

* EXAMPLE ONLY *

Sketch Map of Temperature Station Site

(1:24,000 topo map scale)



USGS 7.5 min Topographic Map Name "GREENWATER" 40 ft. CI

Form 8.0 Error Checked by: AP Date: 10/4/97

All Field Forms Error Checked by: AP Date: 10/4/97

All Data Entry Error Checked by: AP Date: 10/5/97

TFW Monitoring Program

Stream Name SLIPPERY CREEK

Crew Lead AP
Recorder(s) DS ✓ Page 1 of 1

TEMPERATURE SURVEY

DATA LOGGER CALIBRATION

FORM 8.1L

WRIA # 10.0118 | Unlisted Trib ØØØ ○RB ○LB | Segment # 1 | Ø Sub-Segment Code | Station # 14

TI/Probe ID# 18543 #17 — (WATER) Data Logger ● CELSIUS ○ FAHRENHEIT; Make ONSET; Model HOBO-TEMP; Manu. Accuracy (+/-) 0.2 °
Ref. Therm. ● CELSIUS ○ FAHRENHEIT; Make VWR; Model 61099-035; Manu. Accuracy (+/-) 0.1 °

TI/Probe ID# 18547 #19 — (AIR) Data Logger ● CELSIUS ○ FAHRENHEIT; Make ONSET; Model HOBO TEMP; Manu. Accuracy (+/-) 0.2 °
Ref. Therm. ● CELSIUS ○ FAHRENHEIT; Make SAME; Model; Manu. Accuracy (+/-) ____ °

PRE Date 6/25/97 — Bath ● Roomtemp ○ Ice ○ Sand ○ Span
POST Date 10/3/97 — Bath ● Roomtemp ○ Ice ○ Sand ○ Span
PRE Date 6/25/97 — Bath ● Roomtemp ○ Ice ○ Sand ○ Span
POST Date 10/3/97 — Bath ● Roomtemp ○ Ice ○ Sand ○ Span

PRE Time	Ref Therm°	TI°	Diff°	POST Time	Ref Therm°	TI°	Diff°	PRE Time	Ref Therm°	TI°	Diff°	POST Time	Ref Therm°	TI°	Diff°
1208	17.5	17.5	Ø	1410	21.2	21.3	+0.1	1208	17.5	17.6	0.10	1410	21.2	21.3	+0.1
1210				1412				1210				1412			
1212				1414	↓		↓	1212				1414	↓		↓
1214				1416	21.3		Ø	1214				1416	21.3		Ø
1216				1418				1216				1418			
1218	↓		↓	1420		*		1218	↓		↓	1420			
1220	17.6		-0.1	1422	EXAMPLE			1220	17.6		Ø	1422			
1222				1424		ONLY		1222				1424			
1224				1426		*		1224				1426			
1226				1428		↓	↓	1226				1428			
1228				1430		21.2	-0.1	1228				1430			
1230				1432				1230				1432			
1232				1434				1232				1434			
1234				1436				1234				1436			
1236	↓	↓	↓	1438	↓	↓	↓	1236	↓	↓	↓	1438	↓	↓	↓

● Accept ○ Reject — Mean Diff -0.06
● Accept ○ Edit/Reject — Mean Diff -0.01
● Accept ○ Reject — Mean Diff +0.04
● Accept ○ Edit/Reject — Mean Diff +0.02

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ERROR CHECKED by: AP Date: 10/3/97

5/19/99 forms\99\F8-1L.p65

TFW Monitoring Program

Stream Name SLIPPERY CREEK

Crew Lead AP
Recorder(s) ___

TEMPERATURE SURVEY — MAX/MIN CALIBRATION — FORM 8.1M

WRIA # 10.0118 | Unlisted Trib ØØØ ○RB ○LB | Segment # 4 | Ø Sub-Segment Code | Station # 15

TI/Probe ID# MM003 (WATER)

Max/Min Therm. ○CELSIUS ●FAHRENHEIT
Make TAYLOR
Model MAX/MIN
Manu. Accuracy (+/-) 2°

Ref. Therm. ○CELSIUS ●FAHRENHEIT
Make VWR
Model 61099-047
Manu. Accuracy (+/-) 0.1°

PRE

Date 6/25/97 *EXAMPLE ONLY*

Bath	Time	Ref Therm °	Thermometer Max °	Thermometer Min °	Diff Max °	Diff Min °	Pin Max °	Pin Min °
#1	1810	68.5	68	68	0.5		68	
#2	1840	0.2	0	0		0.2	68	0
6/26 #3	0830	66.4	66	66	0.4			0

↑ W/IN Accuracy

Max Pin Difference Ø°
Min Pin Difference Ø°

● Accept
○ Reject

POST

Date 10/3/97

Bath	Time	Ref Therm °	Thermometer Max °	Thermometer Min °	Diff Max °	Diff Min °	Pin Max °	Pin Min °
#1	1800	66.7	66	66	0.7		66	
#2	1830	0.1	0	0		0.1	66	0
10/4 #3	0900	69.5	70	70	-0.5			0

Max Pin Difference Ø°
Min Pin Difference Ø°

● Accept
○ Edit/Reject

TI/Probe ID# N/A

Max/Min Therm. ○CELSIUS ○FAHRENHEIT
Make ___
Model ___
Manu. Accuracy (+/-) ___°

Ref. Therm. ○CELSIUS ○FAHRENHEIT
Make ___
Model ___
Manu. Accuracy (+/-) ___°

PRE

Date __/__/__

Bath	Time	Ref Therm °	Thermometer Max °	Thermometer Min °	Diff Max °	Diff Min °	Pin Max °	Pin Min °
#1								
#2								
#3								

Max Pin Difference ___°
Min Pin Difference ___°

○ Accept
○ Reject

POST

Date __/__/__

Bath	Time	Ref Therm °	Thermometer Max °	Thermometer Min °	Diff Max °	Diff Min °	Pin Max °	Pin Min °
#1								
#2								
#3								

Max Pin Difference ___°
Min Pin Difference ___°

○ Accept
○ Edit/Reject

Stream Name SLIPPERY CREEK

Crew Lead AP
Recorder(s) DS / —

TEMPERATURE SURVEY — STATION DOCUMENTATION — FORM 8.2

WRIA # 10.0118 | Unlisted Trib 000 ○RB ○LB | **Segment #** 1 | Ø Sub-Segment Code | **Station #** 14

Water
TI/Probe ID # 18543 #17

Launch Date 7/10/97
Launch Time 1800
Interval Frequency 1 hr
Reading Mode ○ Point ● Max ○ Mean ○ Other ______

Download Date 9/30/97
Download Time 0900

EXAMPLE ONLY

Air
TI/Probe ID # 18547 #19

Launch Date 7/10/97
Launch Time 1815
Interval Frequency 1 hr
Reading Mode ○ Point ● Max ○ Mean ○ Other ______

Download Date 9/30/97
Download Time 0930

TI Installation

Begin Survey Date & Time 7/11/97 1447

Site Info
Bankfull Width 10.2 (M) - F
Wetted Width 4.7
Canopy Closure 99 %
96 94 94 96
UP LB DN RB

Water Info
Temperature (pocket thermometer) 12.5 °(C) - F
Depth @ TI 0.46 m
TI Height (above channel bed) 0.12 m

Air Info
Temperature (pocket thermometer) 20 °C
TI Height (above water surface) 1.4 m
TI Distance (from BFCE) 2.5 m

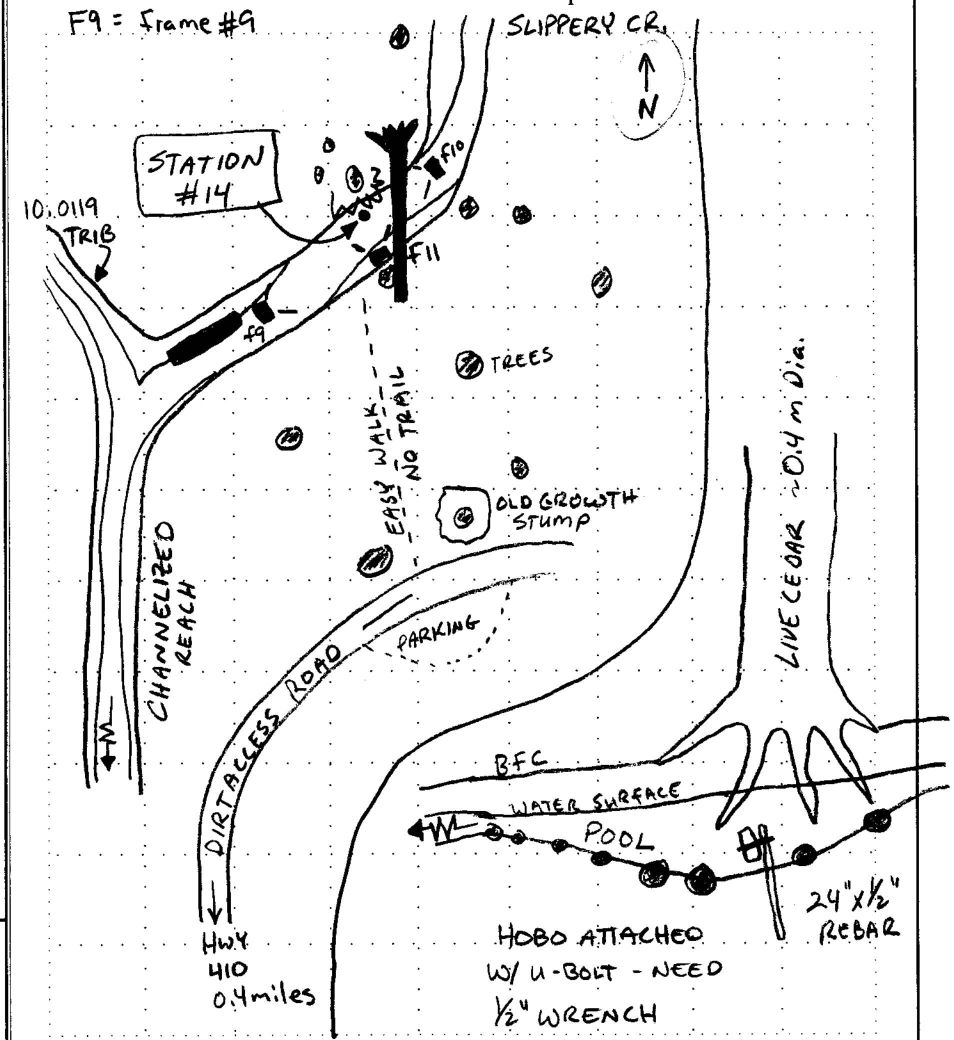
Weather Conditions SUNNY/LIGHT BREEZE

Photographs
Roll # 015 Frame # & Info
#9 10m DOWNSTREAM LOOKING UPSTREAM AT STATION - DS POINTING W/STADIA
#10 5m UPSTREAM LOOKING DOWN AT STATION - DS POINTING W/STADIA
#11 FROM LB LOOKING AT STATION ON RB - DS W/STADIA

TI Removal

End Survey Date & Time 9/29/97 1830

Sketch Map of Installation Site and Notes



ERROR CHECKED by: AP Date: 10/4/97

Stream Name SLIPPERY CREEK

Crew Lead AP
Recorder(s) ____

TEMPERATURE SURVEY

DATA LOGGER FIELD CHECK

FORM 8.2L

WRIA # 10.0118 | Unlisted Trib ØØØ ○RB ○LB | Segment # 1 | Ø Sub-Segment Code | Station # 14

Water TI/Probe ID # 18543 #17
Air TI/Probe ID # 18547 #19

Measurement Units: ● CELSIUS ○ FAHRENHEIT ● METERS ○ FEET

Station Check #	1	2	3	4	• END	OF FIELD	CHECKS •	
Date	7/29/97	8/12/97	8/27/97	9/29/97				
Time	1015	0945	0930	1000				
Site								
Wetted Width	4.5	4.1	3.7	4.2				
Water								
Temperature @ TI (pocket therm.)	13.7	14.9	14.1	14.6				
Depth @ TI	0.44	0.41	0.35	0.40				
TI Height (above channel bed)	0.12	0.12	0.10	0.10				
Download (Y/N)	N	(Y)	N	N				
Air								
Temperature @ TI (pocket therm.)	18°	19°	22°	17°				
TI Height (above water surface)	1.4	1.4	1.5	1.4				
Download (Y/N)	N	(Y)	N	N				
Weather Conditions	FOGGY	CLOUDY & MILD	SUNNY & HOT	SUNNY & WINDY				
Notes	• NO PROBLEMS	• DOWNLOADED AT 1005	• REBAR HAD LOOSENED SO RE-ESTABLISHED AT SAME SITE W/LONGER REBAR	• REBAR SECURE • REMOVED STATION				

* EXAMPLE ONLY *

ERROR CHECKED by: AP Date: 10/4/97

TFW Monitoring Program

Stream Name SLIPPERY CREEK

Crew Lead AP
Recorder(s) DS / Page 1 of 1

TEMPERATURE SURVEY

MAX/MIN DATA

FORM 8.2M

WRIA # 10.0118 Unlisted Trib ØØØ ○RB ○LB **Segment #** 4 Ø Sub-Segment Code **Station #** 15

Water TI/Probe ID # MM003
Air TI/Probe ID # N/A

Measurement Units
○ CELSIUS ● FAHRENHEIT ● METERS ○ FEET

Station Check #	1	2	3	4	• END	of FIELD	CHECKS	
Date	7/29/97	8/12/97	8/27/97	9/29/97				
Time	1115	1030	1045	1115				
Site								
Wetted Width	4.0	3.9	3.5	3.8				
Water								
Max Temp Pin	59°	62°	66°	64°				
Min Temp Pin	50°	54°	52°	49°				
TI Temp	53°	56°	58°	51°				
Temperature @ TI (pocket therm.)	53°	56°	58°	51°				
Depth @ TI	0.34	0.31	0.29	0.30				
TI Height (above channel bed)	0.10	0.10	0.10	0.10				
Air								
Max Temp Pin	X	X	X	X				
Min Temp Pin	X	X	X	X				
TI Temp	X	X	X	X				
Temperature @ TI (pocket therm.)	65°	72°	80°	68°				
TI Height (above water surface)	1.5m	1.5m	1.5m	1.5m				
Weather Conditions	CLOUDY DRIZZLE LIGHT BREEZE	P. CLOUDY NO WIND	CLEAR NO WIND	CLEAR WINDY				
Notes	• REPLACED ROCK CAIRN WITH PVC CASE/REBAR	• NO DISTURBANCE OBSERVED (NDO)	• NDO	• REMOVED STATION • NDO		*EXAMPLE ONLY*		

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5/19/99 forms\99\F8-2M.p65

TFW Monitoring Program

Stream Name SLIPPERY CREEK

Crew Lead AP
Recorder(s) DS
Page 1 of 1

TEMPERATURE SURVEY

THERMAL REACH
SURVEY DESCRIPTION

FORM 8.3

WRIA # 10.0118 | Unlisted Trib ØØØ ○RB ○LB | **Segment #** 1 | Ø Sub-Segment Code | **Station #** 14

Thermal Reach Information

Water TI/Probe ID # 18543 #17
Air TI/Probe ID # 18547 #19

Begin Survey Date 7/11/97

Thermal Reach Length 600 (M) F

Mid Reach Elevation 1720 M (F)

Groundwater Inflow Rate
Upstream 12.41
Downstream 13.10 CMS (CFS)

Transect Interval 25 (M) F

Dominant Land Use MANAGED FOREST

Reach Notes

*

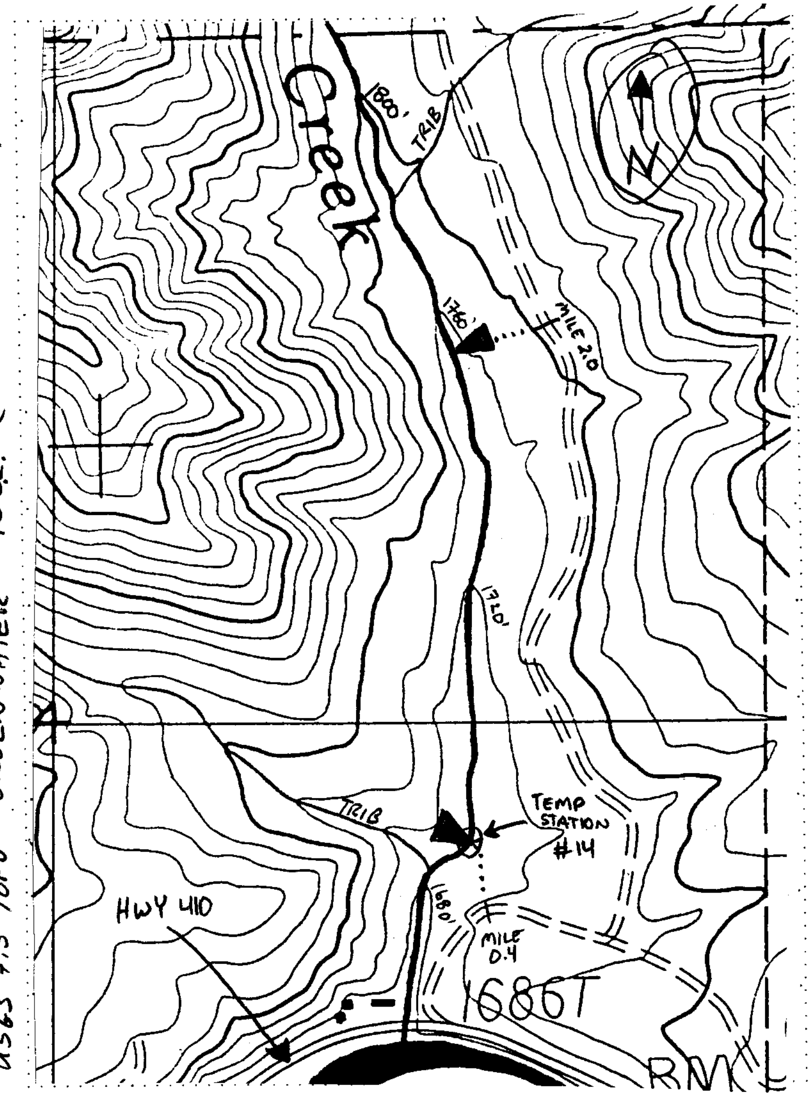
EXAMPLE

ONLY

*

*SPHERICAL DENSIOMETER MODIFIED
AS PER '98 TFW REF. PT. SURVEY - USED
W/TRIPOD É TALLY COUNTER

Sketch Map of Thermal Reach Site



USGS 7.5 TOPO "GREENWATER" 40'C.I. (ENLARGED 320%)

Equipment ● Meters ○ Feet	Type	Size	Cond	Accuracy	Pre-Calibrated	Post-Calibrated
HIPCHAIN ID# H4	CHAINMAN II	STND	GOOD	± 2%	5/4/97	8/30/97
FIBERGLASS TAPE # 037	KESON	30.0	↓	± 0.01	↓	↓
STADIA ROD # 007	MOUND CITY	5.0		± 0.01		
* SPHERICAL DENSIOMETER # 005	CONVEX	STND		——		
COMPASS	SUNNTO MC-1	POCKET	[TRUE	21° E	DECLINATION]	
ABNEY LEVEL # 052	LIETZ 5047-15	0° to ±90°		± 1°		
FLOW METER	SWOFFER 2100					
CHEST WADERS						

TFW Monitoring Program

Stream Name SLIPPERY CREEK

Crew Lead AP
Recorder(s) DS —

TEMPERATURE SURVEY

● METERS ○ FEET

THERMAL REACH CHARACTERISTICS

FORM 8.3R

WRIA # 10.0118 | Unlisted Trib 000 ○RB ○LB | Segment # 1 | Ø Sub-Segment Code | Date 7/11/97

Begin Survey Date 7/11/97
Station # 14

Tran #	Cum Dist	BFW	BFD	WW	WD	Canopy Closure Up	LB	Dn	RB	%	Grad	Chan Type
1	Ø	10.5	0.50	6.3	0.33	45	86	70	16	56	~~2%~~	/
2	25	12.0	0.59	7.1	0.36	86	84	86	85	87	1.5%	/
3	50	11.5	0.78	5.2	0.44	66	89	27	81	68	2.5%	/
4	75	13.2	0.83	5.7	0.49	73	25	48	01	38	1.0%	/

Transect 1

NO GRADIENT
ADJ. BFW +3 m Upstream

1.05 Tape Stations (0.53)(1.58)(2.63)(3.68)(4.73)(5.78)(6.83)(7.88)(8.93)(9.98)
BFD Measurements (0.75)(0.43)(0.35)(0.35)(0.55)(1.15)(0.42)(0.37)(0.40)(0.20)

0.63 Tape Stations (0.32)(0.95)(1.58)(2.21)(2.84)(3.47)(4.10)(4.73)(5.36)(5.99)
WD Measurements (0.10)(0.15)(0.25)(0.25)(0.60)(0.85)(0.40)(0.30)(0.25)(0.15)

RMZ	RB	LB
Width	15	20
Cover	M	C
Size	M	L
Density	S	D
Wind	Y	N

Field Notes • TRAN #1 STARTS AT TEMPERATURE STATION #14
EXAMPLE ONLY

Transect 2

GRADIENT TRAN#1 – #2
ADJ. BFW +5.0 m UPSTREAM

1.20 Tape Stations (0.60)(1.80)(3.00)(4.20)(5.40)(6.60)(7.80)(9.00)(10.20)(11.40)
BFD Measurements (0.63)(0.65)(0.62)(0.63)(0.80)(0.42)(0.25)(0.65)(0.65)(0.62)

0.71 Tape Stations (0.36)(1.07)(1.78)(2.49)(3.20)(3.91)(4.62)(5.33)(6.04)(6.75)
WD Measurements (0.35)(0.45)(0.25)(0.25)(0.25)(0.50)(0.50)(0.35)(0.35)(0.35)

RMZ	RB	LB
Width	20	25
Cover	M	M
Size	S	M
Density	S	S
Wind	Y	Y

Field Notes
• POOL MODIFIED BY HUMAN
• PARTIAL SHADE BY WINDTHROW

Transect 3

1.15 Tape Stations (0.58)(1.73)(2.88)(4.03)(5.18)(6.33)(7.48)(8.63)(9.78)(10.93)
BFD Measurements (1.17)(1.13)(1.20)(0.50)(0.35)(0.25)(0.37)(0.78)(1.05)(1.03)

0.52 Tape Stations (0.26)(0.78)(1.30)(1.82)(2.34)(2.86)(3.38)(3.90)(4.42)(4.94)
WD Measurements (0.63)(0.55)(0.40)(0.32)(0.30)(0.35)(0.42)(0.55)(0.45)(0.40)

RMZ	RB	LB
Width	10	20
Cover	D	D
Size	S	M
Density	S	S
Wind	Y	Y

Field Notes
• YARDING CORRIDOR CROSSING

Transect 4

ADJ. BFW 2 m DOWNSTREAM

1.32 Tape Stations (0.66)(1.98)(3.30)(4.62)(5.94)(7.26)(8.58)(9.90)(11.22)(12.54)
BFD Measurements (0.68)(1.03)(0.98)(0.73)(0.58)(0.77)(0.98)(0.57)(1.28)(0.67)

0.57 Tape Stations (0.29)(0.86)(1.43)(2.00)(2.57)(3.14)(3.71)(4.28)(4.85)(5.42)
WD Measurements (0.95)(0.85)(0.55)(0.63)(0.50)(0.25)(0.33)(0.30)(0.35)(0.20)

RMZ	RB	LB
Width	12	16
Cover	D	D
Size	S	M
Density	S	M
Wind	Y	N

Field Notes

Appendix C

Standard Field and Vehicle Gear Checklist Copy Master

(Keep original copy master with manual)

✔ STANDARD FIELD GEAR

- ☐ Field clip board/form holder
- ☐ Survey Forms (on waterproof paper)
- ☐ Copy of survey methods
- ☐ Maps- topographic and road
- ☐ Pencils & erasers
- ☐ Permanent ink marker
- ☐ Calculator
- ☐ 150 mm ruler
- ☐ Pocket field notebook

- ☐ Survey Vest
- ☐ Compass
- ☐ Safety whistle
- ☐ Spring clips (2)
- ☐ Vinyl flagging
- ☐ Pocket knife/multi-purpose tool

- ☐ Backpack or canvas tote bag
- ☐ First aid kit
- ☐ Water bottle and/or filtration system
- ☐ Food/energy bars
- ☐ Rain gear
- ☐ Leather gloves
- ☐ Safety glasses
- ☐ Bug repellant
- ☐ Sun screen
- ☐ Small flashlight or headlamp
- ☐ Matches/fire starter
- ☐ Emergency blanket
- ☐ Snake bite kit (eastern Washington)

✔ STANDARD VEHICLE GEAR

- ☐ Waterproof plastic tote box
- ☐ Backup fiberglass tape
- ☐ Comprehensive first aid kit
- ☐ Rain tarp
- ☐ Rope (100 ft.)
- ☐ Extra water
- ☐ Extra food
- ☐ Extra dry clothes
- ☐ Extra batteries

- ☐ Spare tire/jack/tire iron
- ☐ Tire sealant/inflator
- ☐ Tow strap
- ☐ Come-along winch
- ☐ Fire shovel
- ☐ Fire extinguisher
- ☐ CB radio (to monitor logging activity)
- ☐ Cell phone/VHF radio
- ☐ Brush cutter
- ☐ Ax/bow saw/chain saw
- ☐ Tire chains

✔ For remote work, extra survival & safety gear is recommended.

This gear list is provided as a guideline for outfitting field crews and is not intended to cover all situations. Local conditions may require additional or different gear.

Appendix D

Data Management Examples

EXAMPLE: Excel Entry Sheet

TFW Monitoring										
Temperature Survey Header										
wria basin	wria stream	trib	segment	sub-segment	begin survey date (install)	temp station num	end survey date (remove)	leader first name	leader last name	leader affil-iation
>>>>										
recorder first name	recorder last name	recorder affiliation	air thermo-graph make	air thermo-graph model	air thermo-graph id number	air pre-svy calib date	air post-svy calib date	water thermo-graph make	water thermo-graph model	water thermo-graph id number
>>>>										
water pre-svy calib date	water post-svy calib date	station river mile	town-ship	sec-tion	range	qtr of qtr sect	qtr sec-tion	temp station elev	temp station elev units	water class
>>>>										
Thermal Reach Documentation Information										
temp region	ther-mal reach length	reach mid point elev	elev-ation units	down-stream dis-charge	up-stream dis-charge	dis-charge unit	temp field notes			

EXAMPLE: Excel Entry Sheet

TFW Monitoring										
Temperature - Thermal Reach Characteristics Data (Canopy-Channel Table)										
wria basin	wria stream	trib	seg ment	sub-segment	begin survey date	temp station number	tran-sect number	cumu-lative dis-tance	bank-full width	bank-full depth
>>>>										
wetted width	wetted depth	up-stream canopy closure	right bank canopy closure	down-stream canopy closure	left bank canopy closure	percent canopy closure	multi-channel canopy closure	right bank RMZ width	left bank RMZ width	grad-ient
>>>>										
chan-nel type	field notes									

EXAMPLE: Excel Entry Sheet

TFW Monitoring										
Temperature - Max/Min Data										
wria basin	wria stream	trib	seg ment	sub-segment	begin survey date	temp station number	temp data type	read-ing date	read-ing time	maxi-mum temp
>>>>										
mini-mum temp										

TFW Monitoring

Temperature Survey Air Project Summary Report

Stream Name:

WRIA: 37 . 1388 .001

Survey Date: 05/07/1997 to 07/07/1997

Segment: 17 sub: 0

Station Num: 24

Station Location: T R Sec Qtr of the Qtr

Midpoint Elev: 1610 F

River Mile: 12.500

Station Elev: 1580 F

Thermal Reach Length:

Air Make: Onset

Survey Leader:

Air Model: Stowaway

Affiliation: NWIFC

Air ID Number: b14

Air Pre/Post Calib Dates: -

Discharge (CFS):

Downstream: 17.0000

Upstream: 15.5000

Change: 1.5000

Monitoring Project Period	# Of Days With Readings	Maximum Temperature	Mean Daily Maximum Temperature	Minimum Temperature	Mean Daily Minimum Temperature	Mean Temperature	Greatest Daily Temperature Change	Average Daily Temperature Change
05/07/1997 07/07/1997	62	20.74	17.72	13.27	14.80	16.23	4.35	2.92

TFW Monitoring

Temperature Survey Air Daily Summary Report

Stream Name:

WRIA: 37 . 1388 .001

Survey Date: 05/07/1997 to 07/07/1997

Segment: 17 sub: 0

Station Num: 24

Station Location: T R Sec Qtr of the Qtr

River Mile: 12.500

Midpoint Elev: 1610 F

Station Elev: 1580 F

Thermal Reach Length:

Air Make: Onset

Air Model: Stowaway

Air ID Number: b14

Air Pre/Post Calib Dates: -

Survey Leader:

Affiliation: NWIFC

Discharge (CFS):

Downstream: 17.0000

Upstream: 15.5000

Change: 1.5000

Reading Date	# Of Readings Per Date	Daily Maximum Temperature	Daily Minimum Temperature	Daily Mean Temperature	Daily Temperature Range
05/07/1997	2	16.09	15.31	15.70	0.78
05/08/1997	10	17.02	13.27	15.04	3.75
05/09/1997	10	17.33	13.74	15.43	3.59
05/10/1997	10	17.33	13.74	15.38	3.59
05/11/1997	10	17.33	13.74	15.34	3.59
05/12/1997	10	17.64	13.74	15.45	3.90
05/13/1997	10	17.18	14.21	15.42	2.97
05/14/1997	10	16.87	14.06	15.21	2.81
05/15/1997	10	15.93	14.21	15.07	1.72
05/16/1997	10	17.18	13.90	15.34	3.28
05/17/1997	10	16.71	14.21	15.34	2.50
05/18/1997	10	16.71	13.59	15.09	3.12
05/19/1997	10	17.49	13.74	15.45	3.75
05/20/1997	10	16.40	13.74	14.99	2.66
05/21/1997	10	15.93	13.43	14.82	2.50
05/22/1997	10	16.40	13.43	15.07	2.97
05/23/1997	10	16.56	14.53	15.45	2.03
05/24/1997	10	16.24	13.90	15.06	2.34
05/25/1997	10	15.78	14.06	15.07	1.72
05/26/1997	10	15.93	14.53	15.35	1.40
05/27/1997	10	16.71	14.84	15.75	1.87
05/28/1997	10	16.56	14.68	15.73	1.88
05/29/1997	10	17.33	14.68	16.01	2.65
05/30/1997	10	16.87	14.84	15.78	2.03
05/31/1997	10	17.02	14.99	15.85	2.03

TFW Monitoring

Temperature Survey Air Daily Summary Report

Reading Date	# Of Readings Per Date	Daily Maximum Temperature	Daily Minimum Temperature	Daily Mean Temperature	Daily Temperature Range
06/01/1997	10	16.56	14.53	15.47	2.03
06/02/1997	10	17.49	13.90	15.64	3.59
06/03/1997	10	16.87	14.84	15.67	2.03
06/04/1997	10	16.56	14.84	15.65	1.72
06/05/1997	10	17.49	14.06	15.71	3.43
06/06/1997	10	17.80	14.37	16.13	3.43
06/07/1997	10	17.49	14.68	16.13	2.81
06/08/1997	10	18.27	14.21	16.20	4.06
06/09/1997	10	18.88	14.53	16.66	4.35
06/10/1997	10	18.27	14.99	16.71	3.28
06/11/1997	10	17.96	15.16	16.62	2.80
06/12/1997	10	17.18	15.16	16.15	2.02
06/13/1997	10	19.03	14.84	16.75	4.19
06/14/1997	10	19.34	15.31	17.19	4.03
06/15/1997	10	19.50	15.31	17.39	4.19
06/16/1997	10	18.42	15.93	16.98	2.49
06/17/1997	10	18.42	15.93	16.99	2.49
06/18/1997	10	17.80	14.99	16.43	2.81
06/19/1997	10	16.87	14.53	15.79	2.34
06/20/1997	10	17.64	14.53	16.15	3.11
06/21/1997	10	17.33	14.84	16.17	2.49
06/22/1997	10	17.64	14.21	15.85	3.43
06/23/1997	10	17.49	14.68	16.21	2.81
06/24/1997	10	19.03	14.68	16.80	4.35
06/25/1997	10	18.57	15.31	17.13	3.26
06/26/1997	10	18.73	15.31	17.08	3.42
06/27/1997	10	18.11	14.99	16.80	3.12
06/28/1997	10	18.57	15.47	17.15	3.10
06/29/1997	10	18.11	15.93	17.08	2.18
06/30/1997	10	18.11	15.62	16.91	2.49
07/01/1997	10	19.03	16.09	17.50	2.94
07/02/1997	10	18.73	15.47	17.26	3.26
07/03/1997	10	20.28	16.24	18.17	4.04
07/04/1997	10	20.74	16.87	18.91	3.87
07/05/1997	10	20.74	17.80	19.32	2.94
07/06/1997	10	20.43	17.64	19.01	2.79
07/07/1997	10	20.43	16.56	18.61	3.87

TFW Monitoring

Temperature Survey Air Weekly Summary Report

Stream Name:

WRIA: 37 . 1388 .001

Survey Date: 05/07/1997 to 07/07/1997

Segment: 17 sub: 0

Station Num: 24

Station Location: T R Sec Qtr of the Qtr

Midpoint Elev: 1610 F

River Mile: 12.500

Station Elev: 1580 F

Thermal Reach Length:

Air Make: Onset

Survey Leader:

Air Model: Stowaway

Affiliation: NWIFC

Air ID Number: b14

Air Pre/Post Calib Dates: -

Discharge (CFS):

Downstream: 17.0000

Upstream: 15.5000

Change: 1.5000

Week Number	Start Date - End Date	# Of Days With Readings	Maximum Temp	Mean Daily Maximum Temperature	Minimum Temperature	Mean Daily Minimum Temperature	Mean Temperature	Greatest Daily Temperature Change	Average Daily Temperature Change
19	05/07/1997 05/13/1997	7	17.64	17.13	13.27	13.96	15.39	3.90	3.17
20	05/14/1997 05/20/1997	7	17.49	16.76	13.59	13.92	15.21	3.75	2.83
21	05/21/1997 05/27/1997	7	16.71	16.22	13.43	14.10	15.22	2.97	2.12
22	05/28/1997 06/03/1997	7	17.49	16.96	13.90	14.64	15.74	3.59	2.32
23	06/04/1997 06/10/1997	7	18.88	17.82	14.06	14.53	16.17	4.35	3.30
24	06/11/1997 06/17/1997	7	19.50	18.55	14.84	15.38	16.87	4.19	3.17
25	06/18/1997 06/24/1997	7	19.03	17.69	14.21	14.64	16.20	4.35	3.05
26	06/25/1997 07/01/1997	7	19.03	18.46	14.99	15.53	17.09	3.42	2.93
27	07/02/1997 07/08/1997	6	20.74	20.23	15.47	16.76	18.55	4.04	3.46

TFW Monitoring

Temperature Survey Air Monthly Summary Report

Stream Name:

WRIA: 37.1388 .001

Survey Date: 05/07/1997 to 07/07/1997

Segment: 17 sub: 0

Station Num: 24

Station Location: T R Sec Qtr of the Qtr

River Mile: 12.500

Midpoint Elev: 1610 F

Station Elev: 1580 F

Thermal Reach Length:

Air Make: Onset

Air Model: Stowaway

Air ID Number: b14

Air Pre/Post Calib Dates: -

Survey Leader:

Affiliation: NWIFC

Discharge (CFS):

Downstream: 17.0000

Upstream: 15.5000

Change: 1.5000

Month	# Of Days With Readings	Maximum Temperature	Mean Daily Maximum Temperature	Minimum Temperature	Mean Daily Minimum Temperature	Mean Temperature	Greatest Daily Temperature Change	Average Daily Temperature Change
5	25	17.64	16.74	13.27	14.12	15.37	3.90	2.62
6	30	19.50	17.98	13.90	14.92	16.45	4.35	3.06
7	7	20.74	20.05	15.47	16.67	18.40	4.04	3.39

TFW Monitoring

Temperature Survey Water Project Summary Report

Stream Name: WRIA: 37 . 1388 .001

Survey Date: 05/07/1997 to 07/07/1997 Segment: 17 sub: 0

Station Num: 24

Station Location: T R Sec Qtr of the Qtr Midpoint Elev: 1610 F

River Mile: 12.500 Station Elev: 1580 F

Thermal Reach Length:

Water Make: Onset Survey Leader:

Water Model: Stowaway Affiliation: NWIFC

Water ID Number: a3

Water Pre/Post Calib Dates: -

Discharge (CFS):

Downstream: 17.0000

Upstream: 15.5000

Change: 1.5000

Project Period	# Of Days With Readings	Max Temp	Mean Daily Max Temp	Min Temp	Mean Daily Min Temp	Mean Temp	Max Daily Temp Change	Avg Daily Temp Change	Exceed Water Qual Stand?	Total Days Exceed Water Qual Stand	Total Hours Exceed Water Qual Stand
05/07/1997 07/07/1997	65	21.00	8.27	3.27	5.01	6.61	11.94	3.26	Y	3	21:36

TFW Monitoring

Temperature Survey Water Daily Summary Report

Stream Name:

WRIA: 37.1388 .001

Survey Date: 05/07/1997 to 07/07/1997

Segment: 17 sub: 0

Station Num: 24

Station Location: T R Sec Qtr of the Qtr

River Mile: 12.500

Midpoint Elev: 1610 F

Station Elev: 1580 F

Thermal Reach Length:

Water Make: Onset

Water Model: Stowaway

Water ID Number: a3

Water Pre/Post Calib Dates: -

Survey Leader:

Affiliation: NWIFC

Discharge (CFS):

Downstream: 17.0000

Upstream: 15.5000

Change: 1.5000

Reading Date	# Of Readings Per Date	Daily Maximum Temperature	Daily Minimum Temperature	Daily Mean Temperature	Daily Temperature Change	Water Quality Standard Exceeded?	Total Hours Water Quality Standard Exceeded
05/07/1997	2	6.09	5.31	5.70	0.78	N	
05/08/1997	10	7.02	3.27	5.04	3.75	N	
05/09/1997	10	7.33	3.74	5.43	3.59	N	
05/10/1997	10	7.33	3.74	5.38	3.59	N	
05/11/1997	10	7.33	3.74	5.34	3.59	N	
05/12/1997	10	7.64	3.74	5.45	3.90	N	
05/13/1997	10	7.18	4.21	5.42	2.97	N	
05/14/1997	10	6.87	4.06	5.21	2.81	N	
05/15/1997	10	5.93	4.21	5.07	1.72	N	
05/16/1997	10	7.18	3.90	5.34	3.28	N	
05/17/1997	10	6.71	4.21	5.34	2.50	N	
05/18/1997	10	6.71	3.59	5.09	3.12	N	
05/19/1997	10	7.49	3.74	5.45	3.75	N	
05/20/1997	10	6.40	3.74	4.99	2.66	N	
05/21/1997	10	5.93	3.43	4.82	2.50	N	
05/22/1997	10	6.40	3.43	5.07	2.97	N	
05/23/1997	10	6.56	4.53	5.45	2.03	N	
05/24/1997	10	6.24	3.90	5.06	2.34	N	
05/25/1997	10	5.78	4.06	5.07	1.72	N	
05/26/1997	10	5.93	4.53	5.35	1.40	N	
05/27/1997	10	6.71	4.84	5.75	1.87	N	
05/28/1997	10	6.56	4.68	5.73	1.88	N	
05/29/1997	10	7.33	4.68	6.01	2.65	N	
05/30/1997	10	6.87	4.84	5.78	2.03	N	

TFW Monitoring

Temperature Survey Water Daily Summary Report

Reading Date	# Of Readings Per Date	Daily Maximum Temperature	Daily Minimum Temperature	Daily Mean Temperature	Daily Temperature Change	Water Quality Standard Exceeded?	Total Hours Water Quality Standard Exceeded
05/31/1997	10	7.02	4.99	5.85	2.03	N	
06/01/1997	10	6.56	4.53	5.47	2.03	N	
06/02/1997	10	7.49	3.90	5.64	3.59	N	
06/03/1997	10	6.87	4.84	5.67	2.03	N	
06/04/1997	10	6.56	4.84	5.65	1.72	N	
06/05/1997	10	7.49	4.06	5.71	3.43	N	
06/06/1997	10	7.80	4.37	6.13	3.43	N	
06/07/1997	10	7.49	4.68	6.13	2.81	N	
06/08/1997	10	8.27	4.21	6.20	4.06	N	
06/09/1997	10	8.88	4.53	6.66	4.35	N	
06/10/1997	10	8.27	4.99	6.71	3.28	N	
06/11/1997	10	7.96	5.16	6.62	2.80	N	
06/12/1997	10	7.18	5.16	6.15	2.02	N	
06/13/1997	10	9.03	4.84	6.75	4.19	N	
06/14/1997	10	9.34	5.31	7.19	4.03	N	
06/15/1997	10	9.50	5.31	7.39	4.19	N	
06/16/1997	10	8.42	5.93	6.98	2.49	N	
06/17/1997	10	8.42	5.93	6.99	2.49	N	
06/18/1997	10	7.80	4.99	6.43	2.81	N	
06/19/1997	10	6.87	4.53	5.79	2.34	N	
06/20/1997	10	7.64	4.53	6.15	3.11	N	
06/21/1997	10	7.33	4.84	6.17	2.49	N	
06/22/1997	10	7.64	4.21	5.85	3.43	N	
06/23/1997	10	7.49	4.68	6.21	2.81	N	
06/24/1997	10	9.03	4.68	6.80	4.35	N	
06/25/1997	10	8.57	5.31	7.13	3.26	N	
06/26/1997	10	8.73	5.31	7.08	3.42	N	
06/27/1997	10	8.11	4.99	6.80	3.12	N	
06/28/1997	10	8.57	5.47	7.15	3.10	N	
06/29/1997	10	8.11	5.93	7.08	2.18	N	
06/30/1997	10	8.11	5.62	6.91	2.49	N	
07/01/1997	10	9.03	6.09	7.50	2.94	N	
07/02/1997	10	8.73	5.47	7.26	3.26	N	
07/03/1997	10	10.28	6.24	8.17	4.04	N	
07/04/1997	10	10.74	6.87	8.91	3.87	N	
07/05/1997	10	10.74	7.80	9.32	2.94	N	
07/06/1997	10	10.43	7.64	9.01	2.79	N	
07/07/1997	10	10.43	6.56	8.61	3.87	N	
07/08/1997	10	18.50	6.56	12.13	11.94	Y	4:48
07/09/1997	10	19.60	9.90	14.83	9.70	Y	7:12
07/10/1997	10	21.00	11.70	16.22	9.30	Y	9:36

TFW Monitoring

Temperature Survey Water Weekly Summary Report

Stream Name: | WRIA: 37 . 1388 .001

Survey Date: 05/07/1997 to 07/07/1997 | Segment: 17 sub: 0

Station Num: 24

Station Location: T R Sec Qtr of the Qtr | Midpoint Elev: 1610 F

River Mile: 12.500 | Station Elev: 1580 F

Thermal Reach Length:

Water Make: Onset | Survey Leader:

Water Model: Stowaway | Affiliation: NWIFC

Water ID Number: a3

Water Pre/Post Calib Dates: -

Discharge (CFS):

Downstream: 17.0000

Upstream: 15.5000

Change: 1.5000

Week #	Start Date - End Date	# Of Days With Readings	Max Temp	Mean Daily Max Temp	Min Temp	Mean Daily Min Temp	Mean Temp	Greatest Daily Temp Change	Avg Daily Temp Change	Exceed Water Qual Stand?	Total Days Exceed Water Qual Stand	Total Hours Exceed Water Qual Stand
19	05/07/1997 05/13/1997	7	7.64	7.13	3.27	3.96	5.39	3.90	3.17	N	0	
20	05/14/1997 05/20/1997	7	7.49	6.76	3.59	3.92	5.21	3.75	2.83	N	0	
21	05/21/1997 05/27/1997	7	6.71	6.22	3.43	4.10	5.22	2.97	2.12	N	0	
22	05/28/1997 06/03/1997	7	7.49	6.96	3.90	4.64	5.74	3.59	2.32	N	0	
23	06/04/1997 06/10/1997	7	8.88	7.82	4.06	4.53	6.17	4.35	3.30	N	0	
24	06/11/1997 06/17/1997	7	9.50	8.55	4.84	5.38	6.87	4.19	3.17	N	0	
25	06/18/1997 06/24/1997	7	9.03	7.69	4.21	4.64	6.20	4.35	3.05	N	0	
26	06/25/1997 07/01/1997	7	9.03	8.46	4.99	5.53	7.09	3.42	2.93	N	0	
27	07/02/1997 07/08/1997	7	18.50	11.41	5.47	6.73	9.06	11.94	4.67	Y	1	4:48
28	07/09/1997 07/15/1997	2	21.00	20.30	9.90	10.80	15.53	9.70	9.50	Y	2	16:48

TFW Monitoring

Temperature Survey Water Monthly Summary Report

Stream Name: WRIA: 37 . 1388 .001

Survey Date: 05/07/1997 to 07/07/1997 Segment: 17 sub: 0

Station Num: 24

Station Location: T R Sec Qtr of the Qtr Midpoint Elev: 1610 F

River Mile: 12.500 Station Elev: 1580 F

Thermal Reach Length:

Water Make: Onset Survey Leader:

Water Model: Stowaway Affiliation: NWIFC

Water ID Number: a3

Water Pre/Post Calib Dates: -

Discharge (CFS):

Downstream: 17.0000

Upstream: 15.5000

Change: 1.5000

Month	# Of Days With Readings	Max Temp	Mean Daily Max Temp	Min Temp	Mean Daily Min Temp	Mean Temp	Max Daily Temp Change	Avg Daily Temp Change	Exceed Water Qual Stand?	Total Days Exceed Water Qual Stand	Total Hours Exceed Water Qual Stand
5	25	7.64	6.74	3.27	4.12	5.37	3.90	2.62	N	0	
6	30	9.50	7.98	3.90	4.92	6.45	4.35	3.06	N	0	
7	10	21.00	12.95	5.47	7.48	10.20	11.94	5.47	Y	3	21:36

TFW Monitoring

Thermal Reach Characteristics Summary Report

Stream Name: WRIA: 37 . 1388 .001

Survey Date: 05/07/1997 to 07/07/1997 Segment: 17 sub: 0

Station Num: 24

Station Location: T R Sec Qtr of the Qtr

River Mile: 12.500

Midpoint Elev: 1610 F

Station Elev: 1580 F

Thermal Reach Length:

Survey Leader:

Affiliation: NWIFC

Discharge (CFS):

Downstream:	17.0000
Upstream:	15.5000
Change:	1.5000

Channel Type: Step-pool Channel Average Stream Gradient:

	Mean	Maximum	Minimum
Bankfull Width	5.54	6.30	4.50
Bankfull Depth	0.09	0.12	0.05
Wetted Width	3.33	3.78	2.70
Wetted Depth	0.15	0.15	0.15
RB RMZ Width	25.29	34.00	18.00
LB RMZ Width	25.29	34.00	18.00
Canopy Closure	17.29	38.00	8.00

Appendix E

Washington State Water Quality Standards Classification List

[*Edited for TFW Stream Temperature Survey: 5/99*]

Title 173 WAC
ECOLOGY, DEPARTMENT OF

Chapter 173-201A WAC WATER QUALITY STANDARDS
FOR SURFACE WATERS OF THE STATE OF WASHINGTON

Chapter 173-201A WAC
WATER QUALITY STANDARDS FOR SURFACE WATERS OF THE STATE OF WASHINGTON

Last Update: 11/18/97

WAC 173-201A-010 Introduction.

(1) The purpose of this chapter is to establish water quality standards for surface waters of the state of Washington consistent with public health and public enjoyment thereof, and the propagation and protection of fish, shellfish, and wildlife, pursuant to the provisions of chapter 90.48 RCW and the policies and purposes thereof.
(2) This chapter shall be reviewed periodically by the department and appropriate revisions shall be undertaken.
(3) The water use and quality criteria set forth in WAC 173-201A-030 through 173-201A-140 are established in conformance with present and potential water uses of the surface waters of the state of Washington and in consideration of the natural water quality potential and limitations of the same. Compliance with the surface water quality standards of the state of Washington require compliance with chapter 173-201A WAC, Water quality standards for surface waters of the state of Washington, and chapter 173-204 WAC, Sediment management standards.

[Statutory Authority: Chapter 90.48 RCW. 92-24-037 (Order 92-29), *7 173-201A-010, filed 11/25/92, effective 12/26/92.]

WAC 173-201A-020 Definitions.

The following definitions are intended to facilitate the use of chapter 173-201A WAC:

"Acute conditions" are changes in the physical, chemical, or biologic environment which are expected or demonstrated to result in injury or death to an organism as a result of short-term exposure to the substance or detrimental environmental condition.
"AKART" is an acronym for "all known, available, and reasonable methods of prevention, control, and treatment." AKART shall represent the most current methodology that can be reasonably required for preventing, controlling, or abating the pollutants associated with a discharge. The concept of AKART applies to both point and nonpoint sources of pollution. The term "best management practices," typically applied to nonpoint source pollution controls is considered a subset of the AKART requirement. "The Stormwater Management Manual for the Puget Sound Basin" (1992), may be used as a guideline, to the extent appropriate, for developing best management practices to apply AKART for storm water discharges.
"Background conditions" means the biological, chemical, and physical conditions of a water body, outside the area of influence of the discharge under consideration. Background sampling locations in an enforcement action would be up-gradient or outside the area of influence of the discharge. If several discharges to any water body exist, and enforcement action is being taken for possible violations to the standards, background sampling would be undertaken immediately up-gradient from each discharge. When assessing background conditions in the headwaters of a disturbed watershed it may be necessary to use the background conditions of a neighboring or similar watershed as the reference conditions.
"Best management practices (BMP)" means physical, structural, and/or managerial practices approved by the department that, when used singularly or in combination, prevent or reduce pollutant discharges.
"Bog" means those wetlands that are acidic, peat forming, and whose primary water source is precipitation, with little, if any, outflow.
"Chronic conditions" are changes in the physical, chemical, or biologic environment which are expected or demonstrated to result in injury or death to an organism as a result of repeated or constant exposure over an extended period of time to a substance or detrimental environmental condition.
"Created wetlands" means those wetlands intentionally created from non-wetland sites to produce or replace natural wetland habitat.

"Critical condition" is when the physical, chemical, and biological characteristics of the receiving water environment interact with the effluent to produce the greatest potential adverse impact on aquatic biota and existing or characteristic water uses. For steady-state discharges to riverine systems the critical condition may be assumed to be equal to the 7Q10 flow event unless determined otherwise by the department.

"Damage to the ecosystem" means any demonstrated or predicted stress to aquatic or terrestrial organisms or communities of organisms which the department reasonably concludes may interfere in the health or survival success or natural structure of such populations. This stress may be due to, but is not limited to, alteration in habitat or changes in water temperature, chemistry, or turbidity, and shall consider the potential build up of discharge constituents or temporal increases in habitat alteration which may create such stress in the long term.

"Department" means the state of Washington department of ecology.

"Director" means the director of the state of Washington department of ecology.

"Drainage ditch" means that portion of a designed and constructed conveyance system that serves the purpose of transporting surplus water; this may include natural water courses or channels incorporated in the system design, but does not include the area adjacent to the water course or channel.

"Ecoregions" are defined using EPAs Ecoregions of the Pacific Northwest Document No. 600/3-86/033 July 1986 by Omernik and Gallant.

"Ground water exchange" means the discharge and recharge of ground water to a surface water. Discharge is inflow from an aquifer, seeps or springs that increases the available supply of surface water. Recharge is outflow downgradient to an aquifer or downstream to surface water for base flow maintenance. Exchange may include ground water discharge in one season followed by recharge later in the year.

"Irrigation ditch" means that portion of a designed and constructed conveyance system that serves the purpose of transporting irrigation water from its supply source to its place of use; this may include natural water courses or channels incorporated in the system design, but does not include the area adjacent to the water course or channel.

"Lakes" shall be distinguished from riverine systems as being water bodies, including reservoirs, with a mean detention time of greater than fifteen days.

"Natural conditions" or "natural background levels" means surface water quality that was present before any human-caused pollution. When estimating natural conditions in the headwaters of a disturbed watershed it may be necessary to use the less disturbed conditions of a neighboring or similar watershed as a reference condition.

"Nonpoint source" means pollution that enters any waters of the state from any dispersed land-based or water-based activities, including but not limited to atmospheric deposition, surface water runoff from agricultural lands, urban areas, or forest lands, subsurface or underground sources, or discharges from boats or marine vessels not otherwise regulated under the National Pollutant Discharge Elimination System program.

"Pollution" means such contamination, or other alteration of the physical, chemical, or biological properties, of any waters of the state, including change in temperature, taste, color, turbidity, or odor of the waters, or such discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state as will or is likely to create a nuisance or render such waters harmful, detrimental, or injurious to the public health, safety, or welfare, or to domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or to livestock, wild animals, birds, fish, or other aquatic life.

"Shoreline stabilization" means the anchoring of soil at the water's edge, or in shallow water, by fibrous plant root complexes; this may include long-term accretion of sediment or peat, along with shoreline progradation in such areas.

"Storm water" means that portion of precipitation that does not naturally percolate into the ground or evaporate, but flows via overland flow, interflow, pipes, and other features of a storm water drainage system into a defined surface water body, or a constructed infiltration facility.

"Storm water attenuation" means the process by which peak flows from precipitation are reduced and runoff velocities are slowed as a result of passing through a surface waterbody.

"Surface waters of the state" includes lakes, rivers, ponds, streams, inland waters, saltwaters, wetlands and all other surface waters and water courses within the jurisdiction of the state of Washington.

"Temperature" means water temperature expressed in degrees Celsius (^{0}C).

"USEPA" means the United States Environmental Protection Agency.

"Wetlands" means areas that are inundated or saturated by surface water or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. Wetlands do not include those artificial wetlands intentionally created from nonwetland sites, including, but not limited to, irrigation and drainage ditches, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities, or those wetlands created after July 1, 1990, that were unintentionally created as a result of the construction of a road, street, or highway. Wetlands may include those artificial wetlands intentionally created from nonwetland areas to mitigate the conversion of wetlands. (Waterbodies not included in the definition of wetlands as well as those mentioned in the definition are still waters of the state.)

"Wildlife habitat" means waters of the state used by, or that directly or indirectly provide food support to, fish, other aquatic life, and wildlife for any life history stage or activity.

[Statutory Authority: Chapter 90.48 RCW and 40 CFR 131. 97-23-064 (Order 94-19), *7 173-201A-020, filed 11/18/97, effective 12/19/97. Statutory Authority: Chapter 90.48 RCW. 92-24-037 (Order 92-29), *7 173-201A-020, filed 11/25/92, effective 12/26/92.]

WAC 173-201A-030 General water use and criteria classes.

The following criteria shall apply to the various classes of surface waters in the state of Washington:

(1) Class AA (extraordinary).
(a) General characteristic. Water quality of this class shall markedly and uniformly exceed the requirements for all or substantially all uses.
(b) Characteristic uses. Characteristic uses shall include, but not be limited to, the following:
(i) Water supply (domestic, industrial, agricultural).
(ii) Stock watering.
(iii) Fish and shellfish:
Salmonid migration, rearing, spawning, and harvesting.
Other fish migration, rearing, spawning, and harvesting.
(iv) Wildlife habitat.
(v) Recreation (primary contact recreation, sport fishing, boating, and aesthetic enjoyment).
(vi) Commerce and navigation.
(c) Water quality criteria:
(iv) Temperature shall not exceed 16.0°C (freshwater) due to human activities. When natural conditions exceed 16.0°C (freshwater), no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3°C.
Incremental temperature increases resulting from point source activities shall not, at any time, exceed $t=23/(T+5)$ (freshwater). Incremental temperature increases resulting from nonpoint source activities shall not exceed 2.8°C.
For purposes hereof, "t" represents the maximum permissible temperature increase measured at a mixing zone boundary; and "T" represents the background temperature as measured at a point or points unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge.

(2) Class A (excellent).
(a) General characteristic. Water quality of this class shall meet or exceed the requirements for all or substantially all uses.
(b) Characteristic uses. Characteristic uses shall include, but not be limited to, the following:
(i) Water supply (domestic, industrial, agricultural).
(ii) Stock watering.
(iii) Fish and shellfish:
Salmonid migration, rearing, spawning, and harvesting.
Other fish migration, rearing, spawning, and harvesting.
(iv) Wildlife habitat.
(v) Recreation (primary contact recreation, sport fishing, boating, and aesthetic enjoyment).
(vi) Commerce and navigation.
(c) Water quality criteria:
(iv) Temperature shall not exceed 18.0°C (freshwater) due to human activities. When natural conditions exceed 18.0°C (freshwater), no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3°C.
Incremental temperature increases resulting from point source activities shall not, at any time, exceed $t=28/(T+7)$ (freshwater). Incremental temperature increases resulting from nonpoint source activities shall not exceed 2.8°C.
For purposes hereof, "t" represents the maximum permissible temperature increase measured at a mixing zone boundary; and "T" represents the background temperature as measured at a point or points unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge.

(3) Class B (good).
(a) General characteristic. Water quality of this class shall meet or exceed the requirements for most uses.
(b) Characteristic uses. Characteristic uses shall include, but not be limited to, the following:
(i) Water supply (industrial and agricultural).
(ii) Stock watering.
(iii) Fish and shellfish:
Salmonid migration, rearing, and harvesting.

Other fish migration, rearing, spawning, and harvesting.
(iv) Wildlife habitat.
(v) Recreation (secondary contact recreation, sport fishing, boating, and aesthetic enjoyment).
(vi) Commerce and navigation.
(c) Water quality criteria:
(iv) Temperature shall not exceed 21.0°C (freshwater due to human activities. When natural conditions exceed 21.0°C (freshwater), no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3°C.
Incremental temperature increases resulting from point source activities shall not, at any time, exceed $t=34/(T+9)$ (freshwater). Incremental temperature increases resulting from nonpoint source activities shall not exceed 2.8°C.
For purposes hereof, "t" represents the maximum permissible temperature increase measured at a mixing zone boundary; and "T" represents the background temperature as measured at a point or points unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge.

(4) Class C (fair).
(a) General characteristic. Water quality of this class shall meet or exceed the requirements of selected and essential uses.
(b) Characteristic uses. Characteristic uses shall include, but not be limited to, the following:
(i) Water supply (industrial).
(ii) Fish (salmonid and other fish migration).
(iii) Recreation (secondary contact recreation, sport fishing, boating, and aesthetic enjoyment).
(iv) Commerce and navigation.
(c) Water quality criteria - marine water:
(iii) Temperature shall not exceed 22.0°C due to human activities. When natural conditions exceed 22.0°C, no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3°C.
Incremental temperature increases shall not, at any time, exceed $t=20/(T+2)$.
For purposes hereof, "t" represents the maximum permissible temperature increase measured at a mixing zone boundary; and "T" represents the background temperature as measured at a point or points unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge.

(5) Lake class.
(a) General characteristic. Water quality of this class shall meet or exceed the requirements for all or substantially all uses.
(b) Characteristic uses. Characteristic uses shall include, but not be limited to, the following:
(i) Water supply (domestic, industrial, agricultural).
(ii) Stock watering.
(iii) Fish and shellfish:
Salmonid migration, rearing, spawning, and harvesting.
Other fish migration, rearing, spawning, and harvesting.
(iv) Wildlife habitat.
(v) Recreation (primary contact recreation, sport fishing, boating, and aesthetic enjoyment).
(vi) Commerce and navigation.
(c) Water quality criteria:
(iv) Temperature - no measurable change from natural conditions.

[Statutory Authority: Chapter 90.48 RCW and 40 CFR 131. 97-23-064 (Order 94-19), *7 173-201A-030, filed 11/18/97, effective 12/19/97. Statutory Authority: Chapter 90.48 RCW. 92-24-037 (Order 92-29), *7 173-201A-030, filed 11/25/92, effective 12/26/92.]

WAC 173-201A-060 General considerations.

The following general guidelines shall apply to the water quality criteria and classifications set forth in WAC 173-201A-030 through 173-201A-140 hereof:
(1) At the boundary between waters of different classifications, the water quality criteria for the higher classification shall prevail.
(2) In brackish waters of estuaries, where the fresh and marine water quality criteria differ within the same classification, the criteria shall be applied on the basis of vertically averaged salinity. The freshwater criteria shall be applied at any point where ninety-five percent of the vertically averaged daily maximum salinity values are less than or equal to one part per thousand. Marine criteria shall apply at all other locations; except that the marine water quality criteria shall apply for dissolved oxygen when the salinity is one part per thousand or greater and for fecal coliform organisms when the salinity is ten parts per thousand or greater.
(7) Due consideration will be given to the precision and accuracy of the sampling and analytical methods used as well as existing conditions at the time, in the application of the criteria.
(8) The analytical testing methods for these criteria shall be in accordance with the "Guidelines Establishing Test Procedures for the Analysis of Pollutants" (40 C.F.R. Part 136) and other or superseding methods published and/or approved by the department following consultation with adjacent states and concurrence of the USEPA.

(9) Nothing in this chapter shall be interpreted to prohibit the establishment of effluent limitations for the control of the thermal component of any discharge in accordance with Section 316 of the federal Clean Water Act (33 U.S.C. 1251 et seq.).
(10) The primary means for protecting water quality in wetlands is through implementing the antidegradation procedures section (WAC 173-201A-070).
(a) In addition to designated uses, wetlands may have existing beneficial uses that are to be protected that include ground water exchange, shoreline stabilization, and storm water attenuation.
(b) Water quality in wetlands is maintained and protected by maintaining the hydrologic conditions, hydrophytic vegetation, and substrate characteristics necessary to support existing and designated uses.
(c) Wetlands shall be delineated using the Washington State Wetlands Identification and Delineation Manual, in accordance with WAC 173-22-035.

[Statutory Authority: Chapter 90.48 RCW and 40 CFR 131. 97-23-064 (Order 94-19), *7 173-201A-060, filed 11/18/97, effective 12/19/97. Statutory Authority: Chapter 90.48 RCW. 92-24-037 (Order 92-29), *7 173-201A-060, filed 11/25/92, effective 12/26/92.]

WAC 173-201A-070 Antidegradation.

The antidegradation policy of the state of Washington, as generally guided by chapter 90.48 RCW, Water Pollution Control Act, and chapter 90.54 RCW, Water Resources Act of 1971, is stated as follows:
(1) Existing beneficial uses shall be maintained and protected and no further degradation which would interfere with or become injurious to existing beneficial uses shall be allowed.
(2) Whenever the natural conditions of said waters are of a lower quality than the criteria assigned, the natural conditions shall constitute the water quality criteria.
(3) Water quality shall be maintained and protected in waters designated as outstanding resource waters in WAC 173-201A-080.
(4) Whenever waters are of a higher quality than the criteria assigned for said waters, the existing water quality shall be protected and pollution of said waters which will reduce the existing quality shall not be allowed, except in those instances where:
(a) It is clear, after satisfactory public participation and intergovernmental coordination, that overriding considerations of the public interest will be served;
(b) All wastes and other materials and substances discharged into said waters shall be provided with all known, available, and reasonable methods of prevention, control, and treatment by new and existing point sources before discharge. All activities which result in the pollution of waters from nonpoint sources shall be provided with all known, available, and reasonable best management practices; and
(c) When the lowering of water quality in high quality waters is authorized, the lower water quality shall still be of high enough quality to fully support all existing beneficial uses.
(5) Short-term modification of water quality may be permitted as conditioned by WAC 173-201A-110.

[Statutory Authority: Chapter 90.48 RCW. 92-24-037 (Order 92-29), *7 173-201A-070, filed 11/25/92, effective 12/26/92.]

WAC 173-201A-080 Outstanding resource waters.

Waters meeting one or more of the following criteria shall be considered for outstanding resource water designation. Designations shall be adopted in accordance with the provisions of chapter 34.05 RCW, Administrative Procedure Act.
(1) Waters in national parks, national monuments, national preserves, national wildlife refuges, national wilderness areas, federal wild and scenic rivers, national seashores, national marine sanctuaries, national recreation areas, national scenic areas, and national estuarine research reserves;
(2) Waters in state parks, state natural areas, state wildlife management areas, and state scenic rivers;
(3) Documented aquatic habitat of priority species as determined by the department of wildlife;
(4) Documented critical habitat for populations of threatened or endangered species of native anadromous fish;
(5) Waters of exceptional recreational or ecological significance.

[Statutory Authority: Chapter 90.48 RCW. 92-24-037 (Order 92-29), *7 173-201A-080, filed 11/25/92, effective 12/26/92.]

WAC 173-201A-120 General classifications.

General classifications applying to various surface water bodies not specifically classified under WAC 173-201A-130 or 173-201A-140 are as follows:
(1) All surface waters lying within national parks, national forests, and/or wilderness areas are classified Class AA or Lake Class.
(2) All lakes and their feeder streams within the state are classified Lake Class and Class AA respectively, except for those feeder streams specifically classified otherwise.
(3) All reservoirs with a mean detention time of greater than 15 days are classified Lake Class.
(4) All reservoirs with a mean detention time of 15 days or less are classified the same as the river section in which they are located.
(5) All reservoirs established on preexisting lakes are classified as Lake Class.
(6) All unclassified surface waters that are tributaries to Class AA waters are classified Class AA. All other unclassified surface waters within the state are hereby classified Class A.

[Statutory Authority: Chapter 90.48 RCW. 92-24-037 (Order 92-29), *7 173-201A-120, filed 11/25/92, effective 12/26/92.]

WAC 173-201A-130 Specific classifications--Freshwater.

Specific fresh surface waters of the state of Washington are classified as follows:

(1) American River.	Class AA
(2) Big Quilcene River and tributaries.	Class AA
(3) Bumping River.	Class AA
(4) Burnt Bridge Creek.	Class A
(5) Cedar River from Lake Washington to the Maplewood Bridge (river mile 4.1).	Class A
(6) Cedar River and tributaries from the Maplewood Bridge (river mile 4.1) to Landsburg Dam (river mile 21.6).	Class AA
(7) Cedar River and tributaries from Landsburg Dam (river mile 21.6) to headwaters.	Class AA
(8) Chehalis River from upper boundary of Grays Harbor at Cosmopolis (river mile 3.1, longitude 123°45'45" W) to Scammon Creek (river mile 65.8).	Class A
(9) Chehalis River from Scammon Creek (river mile 65.8) to Newaukum River (river mile 75.2).	Class A
(10) Chehalis River from Newaukum River (river mile 75.2) to Rock Creek (river mile 106.7).	Class A
(11) Chehalis River, from Rock Creek (river mile 106.7) to headwaters.	Class AA
(12) Chehalis River, south fork.	Class A
(13) Chewuch River.	Class AA
(14) Chiwawa River.	Class AA
(15) Cispus River.	Class AA
(16) Clearwater River.	Class A
(17) Cle Elum River.	Class AA
(18) Cloquallum Creek.	Class A
(19) Clover Creek from outlet of Lake Spanaway to inlet of Lake Steilacoom.	Class A
(20) Columbia River from mouth to the Washington-Oregon border (river mile 309.3). Special conditions - temperature shall not exceed 20.0°C due to human activities. When natural conditions exceed 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed 0.3°C due to any single source or 1.1°C due to all such activities combined.	Class A
(21) Columbia River from Washington-Oregon border (river mile 309.3) to Grand Coulee Dam (river mile 596.6). Special condition from Washington-Oregon border (river mile 309.3) to Priest Rapids Dam (river mile 397.1). Temperature shall not exceed 20.0°C due to human activities. When natural conditions exceed 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed $t=34/(T+9)$.	Class A
(22) Columbia River from Grand Coulee Dam (river mile 596.6) to Canadian border (river mile 745.0).	Class AA
(23) Colville River.	Class A
(24) Coweeman River from mouth to Mulholland Creek (river mile 18.4).	Class A
(25) Coweeman River from Mulholland Creek (river mile 18.4) to headwaters.	Class AA
(26) Cowlitz River from mouth to base of Riffe Lake Dam (river mile 52.0).	Class A
(27) Cowlitz River from base of Riffe Lake Dam (river mile 52.0) to headwaters.	Class AA
(28) Crab Creek and tributaries.	Class B
(29) Decker Creek.	Class AA
(30) Deschutes River from mouth to boundary of Snoqualmie National Forest (river mile 48.2).	Class A
(31) Deschutes River from boundary of Snoqualmie National Forest (river mile 48.2) to headwaters.	Class AA
(32) Dickey River.	Class A
(33) Dosewallips River and tributaries.	Class AA
(34) Duckabush River and tributaries.	Class AA

(35) Dungeness River from mouth to Canyon Creek (river mile 10.8). Class A
(36) Dungeness River and tributaries from Canyon Creek (river mile 10.8) to headwaters. Class AA
(37) Duwamish River from mouth south of a line bearing 254° true from the NW corner of berth 3, terminal No. 37 to the Black River (river mile 11.0) (Duwamish River continues as the Green River above the Black River). Class B
(38) Elochoman River. Class A
(39) Elwha River and tributaries. Class AA
(40) Entiat River from Wenatchee National Forest boundary (river mile 20.5) to headwaters. Class AA
(41) Grande Ronde River from mouth to Oregon border (river mile 37). Special condition - temperature shall not exceed 20.0°C due to human activities. When natural conditions exceed 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed t=34/(T+9). Class A
(42) Grays River from Grays River Falls (river mile 15.8) to headwaters. Class AA
(43) Green River (Cowlitz County). Class AA
(44) Green River (King County) from Black River (river mile 11.0 and point where Duwamish River continues as theGreen River) to west boundary of Sec. 27-T21N- R6E (west boundary of Flaming Geyser State Park at river mile 42.3). Class A
(45) Green River (King County) from west boundary of Sec. 27-T21N-R6E (west boundary of Flaming Geyser State Park, river mile 42.3) to west boundary of Sec. 13-T21N-R7E (river mile 59.1). Class AA
(46) Green River and tributaries (King County) from west boundary of Sec. 13-T21N-R7E (river mile 59.1) to headwaters. Class AA
(47) Hamma Hamma River and tributaries. Class AA
(48) Hanaford Creek from mouth to east boundary of Sec. 25-T15N-R2W (river mile 4.1). Class A
(49) Hanaford Creek from east boundary of Sec. 25-T15N-R2W (river mile 4.1) to headwaters. Class A
(50) Hoh River and tributaries. Class AA
(51) Hoquiam River (continues as west fork above east fork) from mouth to river mile 9.3 (Dekay Road Bridge) (upper limit of tidal influence). Class B
(52) Humptulips River and tributaries from mouth to Olympic National Forest boundary on east fork (river mile 12.8) and west fork (river mile 40.4) (main stem continues as west fork). Class A
(53) Humptulips River, east fork from Olympic National Forest boundary (river mile 12.8) to headwaters. Class AA
(54) Humptulips River, west fork from Olympic National Forest boundary (river mile 40.4) to headwaters. Class AA
(55) Issaquah Creek. Class A
(56) Kalama River from lower Kalama River Falls (river mile 10.4) to headwaters. Class AA
(57) Klickitat River from Little Klickitat River (river mile 19.8) to boundary of Yakima Indian Reservation. Class AA
(58) Lake Washington Ship Canal from Government Locks (river mile 1.0) to Lake Washington (river mile 8.6). Lake Class
(59) Lewis River, east fork, from Multon Falls (river mile 24.6) to headwaters. Class AA
(60) Little Wenatchee River. Class AA
(61) Methow River from mouth to Chewuch River (river mile 50.1). Class A
(62) Methow River from Chewuch River (river mile 50.1) to headwaters. Class AA
(63) Mill Creek from mouth to 13th Street Bridge in Walla Walla (river mile 6.4). Class B
(64) Mill Creek from 13th Street Bridge in Walla Walla (river mile 6.4) to Walla Walla Waterworks Dam (river mile 11.5). Class A
(65) Mill Creek and tributaries from city of Walla Walla Waterworks Dam (river mile 21.6) to headwaters. Class AA
(66) Naches River from Snoqualmie National Forestboundary (river mile 35.7) to headwaters. Class AA
(67) Naselle River from Naselle "Falls" (cascade at river mile 18.6) to headwaters. Class AA
(68) Newaukum River. Class A
(69) Nisqually River from mouth to Alder Dam (river mile 44.2). Class A
(70) Nisqually River from Alder Dam (river mile 44.2) to headwaters. Class AA
(71) Nooksack River from mouth to Maple Creek (river mile 49.7). Class A
(72) Nooksack River from Maple Creek (river mile 49.7) to headwaters. Class AA
(73) Nooksack River, south fork, from mouth to Skookum Creek (river mile 14.3). Class A
(74) Nooksack River, south fork, from Skookum Creek (river mile 14.3) to headwaters. Class AA
(75) Nooksack River, middle fork. Class AA
(76) Okanogan River. Class A
(77) Palouse River from mouth to south fork (Colfax, river mile 89.6). Class B
(78) Palouse River from south fork (Colfax, river mile 89.6)to Idaho border (river mile 123.4). Special condition - Class A

temperature shall not exceed 20.0°C due to human activities. When natural conditions exceed 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed t=34/(T+9).

(79) Pend Oreille River from Canadian border (river mile 16.0) to Idaho border (river mile 87.7). Special condition - temperature shall not exceed 20.0°C due to human activities. When natural conditions exceed 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed t=34/(T+9). Class A

(80) Pilchuck River from city of Snohomish WaterworksDam (river mile 26.8) to headwaters. Class AA

(81) Puyallup River from mouth to river mile 1.0. Class B

(82) Puyallup River from river mile 1.0 to Kings Creek (river mile 31.6). Class A

(83) Puyallup River from Kings Creek (river mile 31.6) to headwaters. Class AA

(84) Queets River and tributaries. Class AA

(85) Quillayute River. Class AA

(86) Quinault River and tributaries. Class AA

(87) Salmon Creek (Clark County). Class A

(88) Satsop River from mouth to west fork (river mile 6.4). Class A

(89) Satsop River, east fork. Class AA

(90) Satsop River, middle fork. Class AA

(91) Satsop River, west fork. Class AA

(92) Skagit River from mouth to Skiyou Slough-lower end (river mile 25.6). Class A

(93) Skagit River and tributaries (includes Baker, Suak, Suiattle, and Cascade rivers) rom Skiyou Slough- lower end, (river mile 25.6) to Canadian border (river mile 127.0). Special condition - Skagit River (Gorge by-pass reach) from Gorge Dam (river mile 96.6) to Gorge Powerhouse (river mile 94.2). Temperature shall not exceed 21°C due to human activities. When natural conditions exceed 21°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C, nor shall such temperature increases, at any time, exceed t=34/(T+9). Class AA

(94) Skokomish River and tributaries. Class AA

(95) Skookumchuck River from Bloody Run Creek (river mile 21.4) to headwaters. Class AA

(96) Skykomish River from mouth to May Creek (above Gold Bar at river mile 41.2). Class A

(97) Skykomish River from May Creek (above Gold Bar at river mile 41.2) to headwaters. Class AA

(98) Snake River from mouth to Washington-Idaho-Oregon border (river mile 176.1). Special condition:

(a) Below Clearwater River (river mile 139.3). Temperature shall not exceed 20.0°C due to human activities. When natural conditions exceed 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed t = 34/(t+9).

(b) Above Clearwater River (river mile 139.3). Temperature shall not exceed 20.0°C due to human activities. When natural conditions exceed 20.0°C, no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed 0.3°C due to any single source or 1.1°C due to all such activities combined. Class A

(99) Snohomish River from mouth and east of longitude 122°13'40"W upstream to latitude 47°56'30"N (southern tip of Ebey Island at river mile 8.1). Class A

(100) Snohomish River upstream from latitude 47°56'30"N (southern tip of Ebey Island river mile 8.1) to confluence with Skykomish and Snoqualmie River (river mile 20.5). Class A

(101) Snoqualmie River and tributaries from mouth to west boundary of Twin Falls State Park on south fork (river mile 9.1). Class A

(102) Snoqualmie River, middle fork. Class AA

(103) Snoqualmie River, north fork. Class AA

(104) Snoqualmie River, south fork, from west boundary of Twin Falls State Park (river mile 9.1) to headwaters. Class AA

(105) Soleduck River and tributaries. Class AA

(106) Spokane River from mouth to Long Lake Dam (river mile 33.9). Special condition - temperature shall not exceed 20.0°C due to human activities. When natural conditions exceed 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed t=34/(T+9). Class A

(107) Spokane River from Long Lake Dam (river mile 33.9) to Nine Mile Bridge (river mile 58.0). Special conditions:

(b) Temperature shall not exceed 20.0°C, due to human activities. When natural conditions exceed 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time exceed t=34/(T+9). Lake Class

(108) Spokane River from Nine Mile Class A

Bridge (river mile 58.0) to the Idaho border (river mile 96.5). Temperature shall not exceed 20.0°C due to human activities. When natural conditions exceed 20.0°C no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time exceed t=34/(T+9).

(109) Stehekin River. Class AA

(110) Stillaguamish River from mouth to north and south forks (river mile 17.8). Class A

(111) Stillaguamish River, north fork, from mouth to Squire Creek (river mile 31.2). Class A

(112) Stillaguamish River, north fork, from Squire Creek (river mile 31.2) to headwaters. Class AA

(113) Stillaguamish River, south fork, from mouth to Canyon Creek (river mile 33.7). Class A

(114) Stillaguamish River, south fork, from Canyon Creek (river mile 33.7) to headwaters. Class AA

(115) Sulphur Creek. Class B

(116) Sultan River from mouth to Chaplain Creek (river mile5.9). Class A

(117) Sultan River and tributaries from Chaplain Creek (river mile 5.9) to headwaters. Class AA

(118) Sumas River from Canadian border (river mile 12) to headwaters (river mile 23). Class A

(119) Tieton River. Class AA

(120) Tolt River, south fork and tributaries from mouth to west boundary of Sec. 31-T26N-R9E (river mile 6.9). Class AA

(121) Tolt River, south fork from west boundary of Sec. 31-T26N-R9E (river mile 6.9) to headwaters. Class AA

(122) Touchet River, north fork from Dayton water intake structure (river mile 3.0) to headwaters. Class AA

(123) Toutle River, north fork, from Green River to headwaters. Class AA

(124) Toutle River, south fork. Class AA

(125) Tucannon River from Umatilla National Forest boundary (river mile 38.1) to headwaters. Class AA

(126) Twisp River. Class AA

(127)Union River and tributaries from BremertonWaterworks Dam (river mile 6.9) to headwaters. Class AA

(128) Walla Walla River from mouth to Lowden (Dry Creek at river mile 27.2). Class B

(129) Walla Walla River from Lowden (Dry Creek at river mile 27.2) to Oregon border (river mile 40). Special condition – temperature shall not exceed 20.0°C due to human activities. When natural conditions exceed 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed t=34/(T+9). Class A

(130) Wenatchee River from Wenatchee National Forest boundary (river mile 27.1) to headwaters. Class AA

(131) White River (Pierce-King counties) from Mud Mountain Dam (river mile 27.1) to headwaters. Class AA

(132) White River (Chelan County). Class AA

(133) Wildcat Creek. Class A

(134) Willapa River upstream of a line bearing 70° true through Mailboat Slough light (river mile 1.8). Class A

(135) Wishkah River from mouth to river mile 6 (SW 1/4 SW 1/4 NE 1/4 Sec. 21-T18N-R9W). Class B

(136) Wishkah River from river mile 6 (SW 1/4 SW 1/4 NE1/4 Sec. 21-T18N-R9W) to west fork (river mile 17.7). Class A

(137) Wishkah River from west fork of Wishkah River (river mile 17.7) to south boundary of Sec. 33-T21N-R8W (river mile 32.0). Class AA

(138) Wishkah River and tributaries from outh boundary of Sec. 33-T21N-R8W (river mile 32.0) to headwaters. Class AA

(139) Wynoochee River from mouth to Olympic National Forest boundary (river mile 45.9). Class A

(140) Wynoochee River from Olympic National Forest boundary (river mile 45.9) to headwaters. Class AA

(141) Yakima River from mouth to Cle Elum River (river mile 185.6). Special condition - temperature shall not exceed 21.0°C due to human activities. When natural conditions exceed 21.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature Class A

Appendix F

Sullivan et al., 1990:
Stream Gradient Measurement Method

APPENDIX F

Stream Gradient Measurement Method from Sullivan et al. 1990

Sullivan, K., J.Tooley, K. Doughty, J.E. Caldwell, and P. Knudsen. 1990. Evaluation of prediction models and characterization of stream temperature regimes in Washington. TFW-WQ3-90-006. Washington Dept. Of Natural Resources, Forest Practices Division. Olympia. Page 24.

Stream and Riparian Measurements

Stream and Channel Characteristics

Stream Gradient (%). Stream gradient of channel reaches was measured in several ways to determine a reasonably accurate technique for TFW purposes.

Autolevel Method: Gradient of the lower-most channel reach was measured with an autolevel and story pole. Using standard surveying technique and notation, a difference in water elevation was determined by a backsight and then a foresight to a calibrated story pole resting at water surface. The height of the stationary autolevel was used as the reference point. If necessary, a turning point was made by moving the autolevel to a new stationary point and using the previous foresight location as the next backsight.

Length of backsights and foresights was measured along the course of the stream with a rangefinder. Gradient (or slope) was calculated by dividing the total change in elevation by the total length of the stream course surveyed.

Abney Level Method: Gradient of the uppermost channel reach was measured with an abney level, support pole, and sighting pole. For stability the abney level rested on the support pole with the base of pole at water surface level. The abney level was sighted at another pole of matching length with the base at a different water surface level. For ease in sighting, a fluorescent ribbon was tied to the top of the sighting pole. The slope (gradient) was read from the abney level in degrees and minutes. The length of abney level sighting was measured along the course of the channel reach. Gradient was calculated by conversion to t degrees/minutes multiplied by the weighted length of the sighting. Summing the decimal proportions of the sightings resulted in the length-weighted decimal equivalent slope of the reach.

Digitized Map Method: Gradient of the thermal reach was computed by digitizing the elevations of the lower and upper end of the thermal reach from USGS 1:24,000 (or 1:62,500) topographic maps. The difference in elevations was divided by the length of the thermal reach digitized (typically 600 meters). This method relies on the accuracy and resolution of the topographic contour lines, the accuracy of the stream channel representation on the map, proper placement of sites on maps, as well as the accuracy of digitizing.

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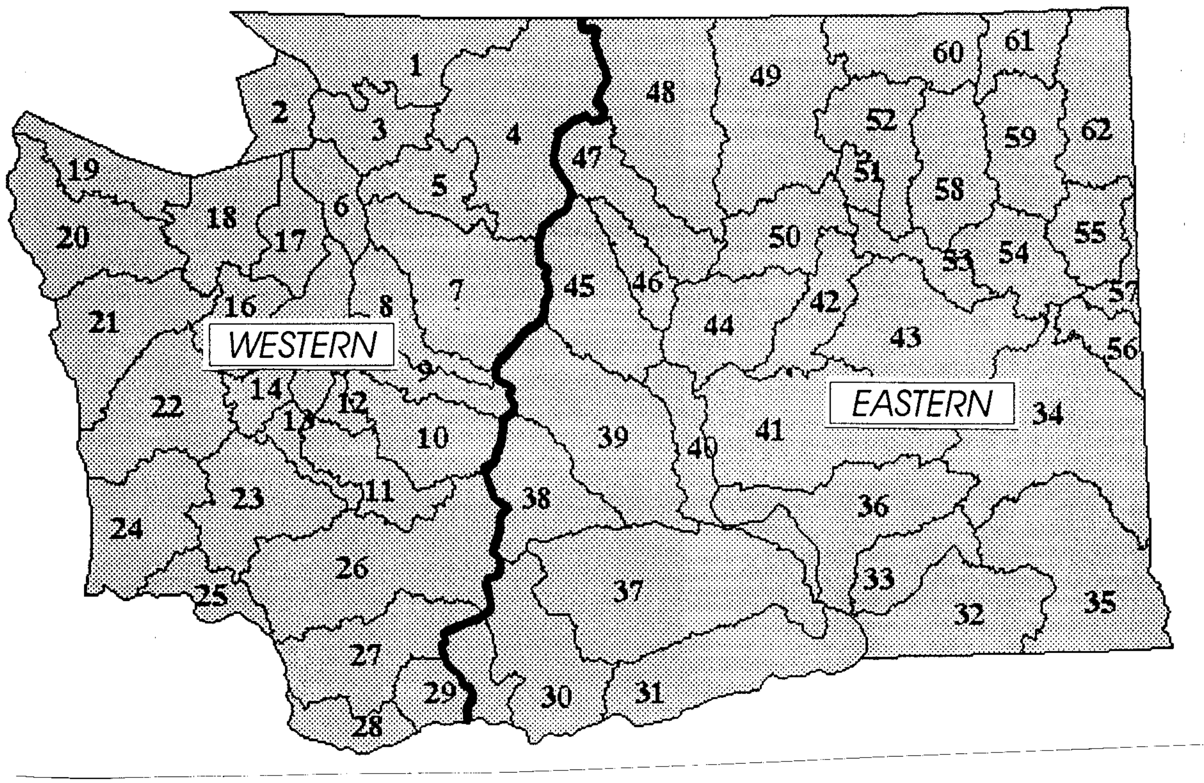
Appendix G

Stream Temperature Regions of Washington Map

APPENDIX G

Stream Temperature Regions of Washington
for Applying TFW Temperature Screens



Water Resource Inventory Areas (WRIA)

Western (**W**): WRIA # 1 - 29

Eastern (**E**): WRIA # 29 - 62