# Draft Scott River Watershed Water Quality Compliance and Trend Monitoring Plan

Prepared by North Coast Regional Water Board Staff

In September of 2006, the *Action Plan for the Scott River Watershed Sediment and Temperature Total Maximum Daily Loads* (Action Plan) was incorporated into the *Water Quality Control Plan for the North Coast Region.* The Action Plan directs Regional Water Board staff to develop a compliance and trend monitoring plan for the Scott River watershed "to determine, on a watershed scale, if water quality standards are being met, and to track progress towards meeting water quality standards." The Action Plan also contains specific direction for Regional Water Board staff:

> "The plan shall include a description of monitoring objectives, parameters to monitor, procedures and techniques, locations of monitoring stations, frequency and duration, quality control and quality assurance protocols, data management procedures, data and analysis distribution procedures, benchmark conditions where available, measurable milestones, and specific due dates for monitoring and data analysis."

This *Draft Scott River Watershed Water Quality Compliance and Trend Monitoring Plan* incorporates the required elements described above.

**Monitoring Objectives**

The overall objective of this monitoring plan is to provide a framework for collection of data that can be used to determine, on a watershed scale, if water quality standards are being met, and to track progress towards meeting water quality standards. The objectives of individual monitoring parameters are explained below.

**Plan Organization**

This plan documents Regional Water Board staff's recommendations to local watershed monitoring practitioners regarding a monitoring framework to achieve the objective stated above. Parameters describing both sediment and temperature related conditions are described. A description of the specific objective, procedures and techniques, locations, frequency and duration, benchmark conditions, and measureable milestones are described for each parameter. These terms are defined in the table below.

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| **Parameter:** | The title and description of the particular metric to be measured. |
| **Objective:** | A description of the specific objective of monitoring the parameter |
| **Procedures and Techniques** | A description of the specific methods, or references describing specific methods, to be used during data collection and analysis. |
| **Locations** | Suggested locations for monitoring the specified parameters |
| **Frequency and Duration** | Suggested frequency and/or duration of measurements. |
| **Benchmark Conditions where available** | A description of current conditions in the Scott River watershed, for each parameter. |
| **Measurable** | A goal for the specified parameter, with a target date for achievement of the |

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| **Milestones** | goal. |

**Sediment-Related Monitoring**

The Scott River Watershed *Staff Report for the Action Plan for the Scott River Watershed Sediment and Temperature Total Maximum Daily Loads* confirmed that sediment-related water quality conditions are contributing to the impairment of beneficial uses in the Scott River watershed. The sediment-related water quality issues that impact beneficial uses in the Scott River watershed relate to both coarse and fine sediment. Coarse sediment loads affect beneficial uses in many ways, including channel aggradation and consequent changes in channel widths and lateral migration. Fine sediment loads also affect beneficial uses in a multitude of ways, including filling of pool habitats, degradation of spawning gravel quality, and impairment of feeding ability of aquatic species.

**Sediment-Related Parameters**

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| **Parameter:** | **Surface particle size distribution (Pebble Counts)**<br>This measure of surface sediment size distribution can be obtained by doing pebble counts. The surface particle size distribution is an effective measure of sediment supply trends. Knopp *et al* (1993) demonstrated that the median particle size (often referred to as "D50") is an effective indicator of sediment supply in north coast streams. The surface particle size distribution has also been demonstrated to be an effective indicator of the balance of sediment supply and sediment transport capacity when compared to the subsurface particle size distribution. One major advantage of this technique is that it is relatively cheap and easy, requiring no special equipment or extensive processing time. |
| **Objective:** | The objective of monitoring surface particle size distribution is to track the trends in both gravel quality and sediment supply. |
| **Procedures and Techniques** | Pebble counts should be conducted in a minimum of 3 riffles, using the methods described in section 4.1.1 of Bunte and Abt (2001). Data analysis should be conducted consistent with methods specified by Bunte and Abt. |
| **Locations** | Regional Water board staff recommend pebble counts at sites where the RCD has previously done McNeil sampling and other reaches with gradients <3%, as shown in figure 1. |
| **Frequency and Duration** | This parameter is an appropriate parameter to measure every 5 years, or the summer low flow period following the next significant water event, whichever occurs first. |
| **Benchmark Conditions where available** | Table 1 presents median surface particle sizes of six Scott River tributaries. |
| **Measurable Milestones** | Knopp *et al* (1993) found a statistically significant difference between the median surface particle sizes of streams with and without extensive management. Their study showed that watersheds without extensive previous management had an average median surface particle size of 63 mm.<br>Milestone: median surface particle size is 63mm or greater by 2046. |

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| **Parameter:** | **Subsurface particle size distribution (McNeil Samples)**<br>This measure of subsurface gravel quality can be obtained by collecting McNeil samples. The subsurface sediment size distribution is an effective measure of sediment conditions as they relate to spawning gravel quality. Previous sampling occurred in 1989, 2000, and 2006. |
| **Objective:** | The objective of measuring the subsurface particle size distribution is to track the trends in subsurface gravel quality as it relates to spawning, primarily. |
| **Procedures and Techniques** | Monitoring should use a McNeil sediment core sampler similar to the specifications found in McNeil and Ahnell (1964), except the diameter of the sampler’s throat should be 2-3 times larger than the largest particle usually encountered. Monitoring should occur according to the protocols found in *Scott River Watershed Monitoring Program – Water Quality: Water Temperature Monitoring and Sediment Sampling and Analysis 2005, 2006, and 2007* (Quigley 2008). A 0.85 mm and a 6.4 mm sieve should be used during sample processing. The wet volumetric method is recommended with the use of the dry gravimetric method on 10% of samples. |
| **Locations** | Regional Water Board staff recommend continuing sampling at sites where the RCD has previously done McNeil sampling, and other reaches with gradients <3%, with a preference for known spawning areas such as spawning reaches of the Scott River canyon. See figure 1 for suggested locations. |
| **Frequency and Duration** | Subsurface particle size distributions are not expected to change greatly from year to year. The collection of subsurface particle size distribution data is costly. Because of the tendency of this parameter to change slowly and the cost of collecting the data, Regional Water Board staff recommend that this parameter be monitored at least every 10 years, or the summer low flow period following the next significant water event, whichever occurs first. The last effort to monitor subsurface particle size distributions occurred in 2006, thus the next survey of this parameter should occur prior to 2016. |
| **Benchmark Conditions where available** | See table 2. |
| **Measurable Milestones** | Regional Water Board staff have reviewed literature pertaining to the appropriate subsurface particle size distributions for support of salmonids (NCRWQCB, 2006). That review determined that ≤14% fines <0.85 mm and ≤30% fines <6.4 mm together provide a benchmark for subsurface gravel quality in relation to salmonid spawning.<br><br>Milestones:<br>• No more than 30% of the gravel subsurface volume has an intermediate diameter of 6.4 mm or less by 2046.<br>• No more than 14% of the gravel subsurface volume has an intermediate diameter of 0.85 mm or less by 2046. |

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| **Parameter:** | **Turbidity**<br>Turbidity is a measure of water clarity and is an inexpensive and commonly used surrogate for measuring suspended sediment concentrations. While turbidity values reflect the effects of any substance that reduces clarity (such as suspended algae, tannins, etc.) those substances are not typically found in the waters of the Scott River watershed (lower Kidder Creek and Big Slough may be exceptions). Thus, turbidity is an appropriate monitoring parameter for tracking suspended sediment trends. |
| **Objective:** | The objective of monitoring turbidity is to track the trends in water quality as it relates to suspended sediment levels by measuring a closely related surrogate. |
| **Procedures and Techniques** | Turbidity data should be collected consistent with protocols described in USGS National Field Manual: (Anderson 2005)<br>Anderson, C.W., 2005, Turbidity, (version 2.1): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6, section 6.7, http://water.usgs.gov/owq/FieldManual/Chapter6/6.7_contents.html. |
| **Locations** | Automated turbidity data collection should occur at the USGS flow gauge near Fort Jones and in the confined reach of Moffett Creek just upstream of Scott Valley. The Quartz Valley Indian Tribe currently operates turbidimeters at both of these locations, in addition to a site on Shackleford Creek |
| **Frequency and Duration** | Measurements should be taken at a frequency no greater than every hour, from November through June. |
| **Benchmark Conditions where available** | Very little turbidity data exists to establish baseline conditions. What data do exist show low turbidity levels, but none describe conditions in Moffett Creek, where turbidity is of most concern. |
| **Measurable Milestones** | Decreasing trend in Moffett Creek turbidity values.<br><br>Klein *et al* (2008) compared turbidity conditions of 27 north coast forested watersheds, using the 10% exceedence level (the turbidity level that was exceeded 10% of the time) as a metric for comparison. Though they analyzed watersheds in a different geological setting than the Scott Watershed, their work is still useful as a point of reference for salmonid streams. Their analysis found that forested watersheds without previous timber harvest (n=12) had an average turbidity level of 13 FNUs at the 10% exceedence level (range = 3 - 22), while watersheds with lower harvest rates (<1.02% annual clearcut equivalent, mean =0.67%) had an average 10% exceedence turbidity of 20 FNUs (range = 4 - 37, n = 5). Watersheds with higher rates of harvest (>1.57% annual clearcut equivalent, mean = 2.35%) had an average 10% exceedence turbidity of 61 FNUs (range = 27 – 116, n=10). |

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| **Parameter:** | **V*** (V-star)<br>V* is a measure of the fraction of a pool's volume that is filled with fine sediment. It has been demonstrated to be an effective measure of pool habitat loss due to fine sediment loading, and has also been demonstrated to be responsive to changes in fine sediment loading in the French Creek watershed. Cover *et al* (2008) demonstrated a statistically significant relationship between the magnitude of sediment loading estimated by USFS cumulative effects models and the value of V* in downstream pools. |
| **Objective:** | The objective of measuring V* is to track trends in fine sediment levels as they relate to pool habitat quality. |
| **Procedures and Techniques** | V* data should be collected as described in Hilton and Lisle (1993). |
| **Locations** | V* monitoring should continue at sites previously monitored by the Siskiyou RCD and French Creek Watershed Advisory Group (WAG), shown in figure 2. |
| **Frequency and Duration** | Every 5 years, or the summer low flow period following the next significant water event, whichever occurs first. |
| **Benchmark Conditions where available** | The Siskiyou RCD and French Creek WAG have collected V* data at various locations in the Scott River watershed in 2006 and 2007. V* values of Scott River tributaries are shown in table 3. Additional information is available in *Scott River Watershed Monitoring Program – Water Quality: Water Temperature Monitoring and Sediment Sampling and Analysis 2005, 2006, and 2007* (Quigley 2008). |
| **Measurable Milestones** | Average V* of all reaches less than 0.20 by 2019, less than 0.17 by 2028, less than 0.13 by 2037, and less than 0.10 by 2046. The three streams identified by Cover *et al* (2008) as having low sediment supplies have an average V* value of 0.064 (range = 0.05 – 0.076). |

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| **Parameter:** | **Channel Cross-Sections**<br>The shape and area of channel cross-sections are responsive to changes in sediment load, and can be used to assess trends in sediment load. |
| **Objective:** | The objective of measuring channel cross-sections is to track trends in channel widths and depths, as well as changes in channel elevations that result from aggradation or degradation. |
| **Procedures and Techniques** | Channel cross-sections should be measured consistent with techniques described in the USFS' General Technical Report RM-245: *Stream Channel Reference Sites: An Illustrated Guide to Field Technique* (1994). |
| **Locations** | Cross-section monitoring should continue at sites previously monitored by the Siskiyou RCD and French Creek Watershed Advisory Group (WAG) in addition to other locations, as shown in figure 3. |
| **Frequency and Duration** | Every five years. |
| **Benchmark Conditions where available** | Scott River channel cross-sections were previously measured by the Siskiyou RCD in 1989 (Sommarstrom *et al*, 1990). Many of the sites were resurveyed since that time, the results of which are reported by *Scott River Watershed Monitoring Program – Water Quality: Water Temperature Monitoring and Sediment Sampling and Analysis 2005, 2006, and 2007* (Quigley 2008). |
| **Measurable Milestones** | n/a |

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| **Parameter:** | **Benthic Macroinvertebrates Abundance: Chironominae and *Attenella delentala***<br>Deposition of fine sediment in streambeds can change the abundance and composition of benthic macroinvertebrate populations. Cover *et al* (2008) found that assemblage and diversity indices commonly used to evaluate biological effects of water quality were not sensitive to fine sediment conditions in the Klamath mountains. They did find, however, that a small subgroup of taxa were significantly correlated with fine sediment levels. Organisms of the Order Chironominae were negatively correlated with fine sediment levels, while the species Attenella delentala were positively correlated with fine sediment levels. |
| **Objective:** | The objective of monitoring the abundance of these specific benthic macroinvertebrates is to track trends in fine sediment levels as they relate to food availability. |
| **Procedures and Techniques** | Procedures for collection and processing of macroinvertebrate samples should be consistent with those described in Cover, *et al* (2008). |
| **Locations** | This data should be collected at the same reaches that V* is monitored. See figure 3. |
| **Frequency and Duration** | Every five years. |
| **Benchmark Conditions where available** | Regional Water Board staff are unaware of data describing current or historic Chironominae and *Attenella delentala* levels. |
| **Measurable Milestones** | n/a |

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| **Parameter:** | **Riffle-Surface Fine Sediment**<br>Cover *et al* (2008) found a significant correlation between the percent of the riffle-surface covered in fine sediment and sediment production model estimates in the Klamath mountains. |
| **Objective:** | The objective of monitoring riffle-surface fine sediment is to track trends in fine sediment levels. |
| **Procedures and Techniques** | Collection and processing of riffle-surface fine sediment data should be done using a sampling grid, consistent with methods described in Cover, *et al* (2008), and Bunte and Abt (2001). |
| **Locations** | This data should be collected at the same reaches that V* is monitored. See figure 3. |
| **Frequency and Duration** | Every five years. |
| **Benchmark Conditions where available** | Regional Water Board staff are unaware of data describing current or historic riffle-surface fine sediment levels. |
| **Measurable Milestones** | Average riffle-surface fine sediment percentage of all reaches less than 10% by 2046.<br><br>The three streams identified by Cover *et al* (2008) as having low sediment supplies have an average riffle-surface fine sediment value of 7.5% (range = 3.7% – 10.2%). |

**Temperature-Related Monitoring**

The dominant controllable factors influencing stream temperatures in the Scott River watershed are streamside shade and groundwater accretion. Progress towards recovering natural levels of streamside shade can be tracked by measuring shade directly or by measuring changes in the extent of riparian vegetation. Changes in the accretion of groundwater to Scott River can be tracked by measuring stream flows at sites distributed longitudinally along the Scott River. Of course the ultimate measure of progress in achieving the goals of the temperature TMDL is the stream temperatures themselves.

**Temperature-Related Parameters**

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| **Parameter:** | **Stream Temperature**<br>Monitoring trends in stream temperature will yield the ultimate measure of beneficial use support and compliance with the water quality objective for temperature. |
| **Objective:** | The objective of monitoring temperature is to establish temperature conditions. |
| **Procedures and Techniques** | Stream temperature data should be collected consistent with SWAMP protocols. |
| **Locations** | Stream temperature measurements should continue to occur at sites previously monitored by the SRCD in Scott Valley, the USFS in the East Fork Scott watershed and Scott River canyon, and private timber companies in the west side tributaries and Moffett Creek, as shown in *Water Temperatures in the Scott River Watershed in Northern California* (Quigley *et al*, 2001). Additional sites should be established nearer to the headwaters of select streams to track the effects of climate change on source temperatures, and downstream of areas of where substantial restoration or management changes are proposed.<br><br>Suggested temperature monitoring locations are presented in figure 4. |
| **Frequency and Duration** | Stream temperatures should be monitored annually from May through September. Sampling interval should be no greater than one hour. |
| **Benchmark Conditions where available** | Table 3 presents historical water temperatures collected at a large number of sites monitored by the Siskiyou RCD. Additional temperature data are reported by Quigley *et al* (2001) and in the Scott TMDL staff report (NCRWQCB, 2005). |
| **Measurable Milestones** | Temperature goals and compliance points for the Scott River cannot currently be determined, due to uncertainty regarding the interaction of groundwater and surface water in Scott Valley. Temperature goals and compliance points should be developed by Regional Water Board staff once the ongoing Scott Valley groundwater study generates sufficient information to do so. |

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| **Parameter:** | **Effective Shade**<br>Effective shade is a useful surrogate measure of solar radiation. The temperature TMDL load allocations are expressed in terms of effective shade. Effective shade is a measure of the amount of the total available solar energy that is blocked by vegetation or topography. Effective shade is not the same as percent canopy measurements commonly used in forestry because percent canopy measures the percent of the entire sky blocked by vegetation, as seen by a viewer on the ground, whereas effective shade measures the percent of the sun's path that is blocked by vegetation or topography and weights the location of the sun's path accordingly based on sunlight intensity through out the day. |
| **Objective:** | The objective of monitoring effective shade is to measure the amount of solar energy reaching a stream. |
| **Procedures and Techniques** | The Solar Pathfinder Quality Assurance Program Plan (see appendix) provides a detailed description of the appropriate procedure for collection of Solar Pathfinder data. |
| **Locations** | Effective shade data should be collected at sites where stream temperatures are monitored (see figure 4), and in reaches affected by management activities, both before and after the proposed activities. |
| **Frequency and Duration** | Effective shade values change as vegetation grows. Given the pace of typical vegetative growth, it's appropriate to measure effective shade every fifth year. |
| **Benchmark Conditions where available** | Regional Water Board staff developed estimates of potential effective shade on perennial streams in the Scott River watershed, adjusted for the effects of fire, windthrow, disease, and other natural disturbances. Those estimates are presented in figure 5. |
| **Measurable Milestones** | The effective shade curves presented in figures 6-8 present the amount of potential effective shade expected under natural conditions, based on vegetation type, stream orientation, and channel width. |

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| **Parameter:** | **Riparian Vegetation Extent**<br>Riparian vegetative extent measured from aerial imagery allows for tracking of progress in re-establishing riparian vegetation communities before the vegetation manifests in effective shade or temperature measurements. An advantage of this type of monitoring is that large areas can be monitored. Another advantage is that riparian vegetation trends can be tracked without the need for extensive time in the field or private property access. |
| **Objective:** | The objective of monitoring vegetative extent is to track changes in near-stream vegetation. |
| **Procedures and Techniques** | Riparian areas should be mapped from aerial imagery with a scale sufficient for identification of individual trees (1:2500 to 1:5000 scale). The mapping should delineate polygons that are distinguished by tree species, canopy density, and tree height. |
| **Locations** | Reaches of the Scott River and tributaries within Scott Valley. |
| **Frequency and Duration** | The extent of riparian vegetation changes as vegetation grows. Given the pace of typical vegetative growth, it's appropriate to measure effective shade every five years. |
| **Benchmark Conditions where available** | Regional Water Board staff mapped near-stream vegetation in Scott Valley as it existed in 2003, using the low level aerial imagery (after rectification) that was collected as part of the FLIR survey. These data are available from Regional Water Board staff as GIS shapefiles. |
| **Measurable Milestones** | n/a |

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| **Parameter:** | **Surface Stream Flow**<br>The Scott River Temperature TMDL identifies the influence of groundwater on surface water temperature as a major factor determining temperatures of the Scott River. Measurements of Scott River flow rates, spaced longitudinally, will aid in the development of understandings of how use of water in the basin affects groundwater accretion, and ultimately water temperatures. |
| **Objective:** | The objective of measuring flow is to track changes in groundwater accretion that affect temperature. |
| **Procedures and Techniques** | Surface stream flow should be measured consistent with the techniques described by Rantz (1982) |
| **Locations** | Stream flow should be measured at Scott River sites previously monitored by SWRCB staff in 1972 & 1973, Regional Water Board staff in 2003, and Siskiyou RCD staff in 2004-2006. Stream flow should be gauged at Young's dam, Island Road, and the USGS gauge. |
| **Frequency and Duration** | Annual surveys in July, August, and September. |
| **Benchmark Conditions where available** | Tables 4-6 present measured Scott River flows at sites distributed along the Scott River in Scott Valley in 1972, 1973, 2003, and 2006. |
| **Measurable Milestones** | Surface streamflow milestones for the Scott River cannot currently be determined, due to uncertainty regarding the interaction of groundwater and surface water in Scott Valley. Surface streamflow goals should be developed by Regional Water Board staff once the ongoing Scott Valley groundwater study generates sufficient information to do so. |

**Quality Control and Quality Assurance Protocols**

Each entity conducting monitoring in support of this plan should develop their own Quality Assurance Project Plan (QAPP) to ensure data quality. Many entities currently conducting monitoring in the Scott River watershed (USFS, QVIR, SRCD, etc.) already have QAPPs developed.

**Data Management, Analysis, and Distribution Procedures**

The Klamath Watershed Institute is developing a web-based data sharing process for data describing fisheries and water quality conditions in the Klamath Basin, through a grant administered by the Regional Water Board. The details of this process and associated infrastructure are still being developed; however, the intent is that this process will be a comprehensive catalog of Klamath Basin water quality and fisheries data. The data collected as part of this Scott River Watershed Water Quality Compliance and Trend Monitoring Plan, and any analyses, should be incorporated in to this larger effort to maintain a comprehensive Klamath Basin data collection.

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Table 1: Median particle size in selected Scott River tributaries representing surface sediment particle size distributions. (USFS, unpublished data)

| Stream | Location | D50 (mm) |
|---|---|---|
| Kelsey Creek | Mouth to 1000 m | 26 |
| Kelsey Creek | 1000 m to 1250 m | 45 |
| Middle Creek | Mouth to 917 m | 56 |
| Pat Ford Creek | Mouth to 450 m | 64 |
| Deep Creek | Mouth to 430 m | 91 |
| Wooliver Creek | Mouth to 1000 m | 25 |
| Mill Creek | from bridge down 1000 m | 64 |

Table 2: Scott River watershed subsurface particle size benchmark conditions (Quigley, 2008)

| | < 6.3 mm | | | < 0.85 mm | | |
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| **Mainstem Sites** | 1989 | 2000 | 2006 | 1989 | 2000 | 2006 |
| Below S. and E Fk Confluence | 30.6 | 32.6 | 20.0 | 6.4 | 4 | 4.7 |
| Below Sugar Ck | - | 18.3 | 18.8 | - | 4 | 5.0 |
| Above Fay Lane | 28.2 | 25.8 | 17.8 | 7.4 | 5.8 | 5.7 |
| Below French Ck | 36.8 | 40.2 | 41.3 | 12.2 | 11.3 | 23.2 |
| Above Etna Ck | 40.1 | 41.6 | 28.7 | 10.5 | 11 | 9.5 |
| Below Etna Ck | 56.7 | 57.6 | 51.1 | 17 | 16.8 | 18.4 |
| Serpa Lane | 82.1 | 75.7 | 75.6 | 21.6 | 14.2 | 16.5 |
| Below Moffett Ck | 36.5 | 36.4 | 35.9 | 11 | 11 | 8.2 |
| Above Shackleford Ck | 41 | 50.5 | 32.5 | 11.1 | 10.4 | 9.1 |
| Below Shackleford Ck | 26.8 | 33.7 | 20.1 | 8 | 7.4 | 6.6 |

| | < 6.3 mm | | | < 0.85 mm | | |
|---|---|---|---|---|---|---|
| **Tributary Sites** | 1989 | 2000 | 2006.0 | 1989 | 2000 | 2006.0 |
| Kangaroo Ck | - | - | 39.7 | - | - | 12.8 |
| East Fk at Ranger Station | - | - | 21.0 | - | - | 5.9 |
| Sugar Creek | 30.8 | 33.8 | 23.2 | 6.3 | 9.9 | 6.8 |
| French Ck at HW3 | 42.6 | 33.9 | 25.2 | 8.2 | 6.9 | 5.5 |
| French Ck WAG site | 33.4 | 46 | 25.9 | 8.2 | 10.9 | 7.6 |
| Etna Ck at HW3 | 28.3 | 16.9 | 30.1 | 5.1 | 2.8 | 5.5 |
| Patterson Ck | - | - | 34.0 | - | - | 6.6 |
| Moffett Ck | - | - | 34.0 | - | - | 7.7 |
| Mill Ck | - | - | 27.2 | - | - | 7.0 |
| Shackleford Ck | - | - | 35.7 | - | - | 7.8 |

Table 3: V* values of Scott River tributaries. (Quigley 2008)

| V* location | Mean V* |
|---|---|
| Rail Creek | 0.27 |
| East Fork | 0.30 |
| Fox Creek | 0.22 |
| South Fork | 0.18 |
| Sugar | 0.13 |
| Miners | 0.53 |
| French | 0.25 |
| Etna | 0.18 |
| Patterson | 0.27 |
| Kidder | 0.16 |
| Moffett | 0.32 |
| Mill | 0.27 |
| Shackleford | 0.23 |
| Mill (Shackleford) | 0.27 |
| Canyon | 0.18 |
| Kelsey | 0.12 |
| Tompkins | 0.29 |
| Mean = | 0.24 |

Table 4: Benchmark Temperature Conditions, Scott River and Tributaries

| **Siskiyou RCD Temperature Monitoring Data - Maximum Weekly Average Temperatures** | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Reach Location** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **Max** | **Avg** |
| **Tributaries** | | | | | | | | | | | | | |
| Lower East Fork | | 14.4 | 19.4 | 21.6 | 21.9 | 21.8 | 22.5 | 21.8 | 21.4 | 21 | | 22.5 | 20.6 |
| Upper Masterson Rd | | 21 | | 21.4 | 20.9 | 21.3 | 22.7 | 21.5 | 21.1 | 21.2 | 21.7 | 22.7 | 21.4 |
| Mouth of Etna Cr. | | 16.3 | | | | 22 | | | | | | 22 | 19.2 |
| Lower French | 20.7 | 19.7 | 18.1 | 21.1 | | 17.1 | 18.9 | | 19.8 | 21.5 | | 21.5 | 19.6 |
| Mid-French | | | | | | 18.2 | 18.2 | | 18.4 | 18.6 | | 18.6 | 18.4 |
| Rail Creek | | 16 | 15.1 | 17.3 | 16.7 | 17.9 | 18.3 | 17.3 | 16.6 | 17.3 | 18.2 | 18.3 | 17.1 |
| Mid-Sugar | | | | | | 16.2 | 16.9 | 18.1 | 17.4 | 17 | 18.2 | 18.2 | 17.3 |
| Lower Shackleford | | | | | | | | 16.6 | | | | 16.6 | 16.6 |
| Lower Mill | | | | | | | | 20.8 | 16.4 | | 16.9 | 20.8 | 18.0 |
| Lower South Fork | | 16.3 | 13.8 | 17.3 | 17.8 | 17.3 | 17.4 | 17.2 | | 16.8 | 17 | 17.8 | 16.8 |
| Upper South Fork | | 14.8 | 13.5 | 15.4 | 15.8 | 15.3 | 15.9 | 15.6 | 15.2 | 15.9 | 15.4 | 15.9 | 15.3 |
| Miners Creek | | | | | | | | | | 17.9 | | 17.9 | 17.9 |
| **Mainstem** | | | | | | | | | | | | | |
| Scott @ Hwy 3 | 21.7 | 21.1 | 19.9 | 22.5 | | 24.2 | | | | | | 24.2 | 21.9 |
| Serpa Lane | 23.1 | | 21 | 23.6 | | | 23.2 | 23.3 | | | | 23.6 | 22.8 |
| Below Black Bridge | 22.1 | 20.5 | 19.9 | 22.5 | | 22 | 21.9 | | 22.5 | | 24.2 | 24.2 | 22.0 |
| Below mouth of Etna | 20.6 | 20 | | 20.6 | | | | | | | | 20.6 | 20.4 |
| Above mouth of Etna | 20.7 | 19.7 | | 17.2 | | 17.6 | | | | | | 20.7 | 18.8 |
| Below mouth of French | 20.9 | 18.2 | 18.7 | 19.1 | | 19 | 20.2 | 19.7 | 19.8 | 19.4 | | 20.9 | 19.4 |
| Above mouth of French | 20.8 | 19.7 | 18.5 | 19.8 | 18 | 20 | 20.3 | 19.9 | 20.3 | | | 20.8 | 19.7 |
| Fay Lane | 19.6 | 19.2 | | 20 | 19.3 | | 20.1 | 19.7 | | | 19.7 | 20.1 | 19.7 |
| Lower tailings(Middle Tailings) | | | | 20.3 | | | 20 | 19.8 | 19.2 | 19.3 | 21.5 | 21.5 | 20.0 |
| Rattlesnake Creek | 21 | | 19.8 | | | 24.2 | 23.3 | 23.3 | | | | 24.2 | 22.3 |
| Scott @ Meamber Cr. | | | 19.8 | 21.8 | 21.4 | 20.7 | 22.4 | 21.3 | 21.2 | | | 22.4 | 21.2 |
| Scott @ Meamber Br. | 22.8 | | 21.2 | | | 21.4 | 23.3 | 21.6 | 21.4 | | 19.9 | 23.3 | 21.7 |

Table 5: Scott River flows in 1972 and 1973, measured and reported by the State Water Resource Control Board (SWRCB, 1974). Units are $ft^3/s$.

| | | 1972 | | | 1973 | | | |
|---|---|---|---|---|---|---|---|---|
| Site | River Mile | **7/9/1972** | **8/9/1972** | **9/8/1972** | **7/3/1973** | **8/1/1973** | **9/5/1973** | **10/2/1973** |
| USGS Gage | 21.6 | **155** | **61** | **69** | **96** | **44** | **23** | **65** |
| Meamber Bridge | 25.2 | **140** | **48** | **54** | **66** | **33** | **13** | **35** |
| Dunlap Ranch | 28.5 | **110** | **33** | **44** | **46** | **19** | **11** | **30** |
| Below SVID Pumps | 31.6 | **90** | **11** | **25** | **23** | **6.4** | **3.8** | **25** |
| Island Road | 35.1 | **68** | **23** | **27** | **30** | **7.2** | **2.3** | **10** |
| Eller Lane | 39.4 | **61** | **24** | **19** | **31** | **20** | **1.3** | **10** |
| Horn Lane | 44.4 | **44** | **16** | **20** | **17** | **9.7** | **7.4** | **7** |
| Fay Lane | 50.3 | **32** | **5** | **3.6** | **24** | **4.8** | **2.3** | **3** |
| Below Wildcat (Red Bridge) | 56 | **53** | **11** | **12** | **43** | **9.5** | **3.3** | **10** |

Table 6: Scott River flows in 2003, measured and reported by Regional Water Board staff (NCRWQCB, 2005). Units are $ft^3/s$.

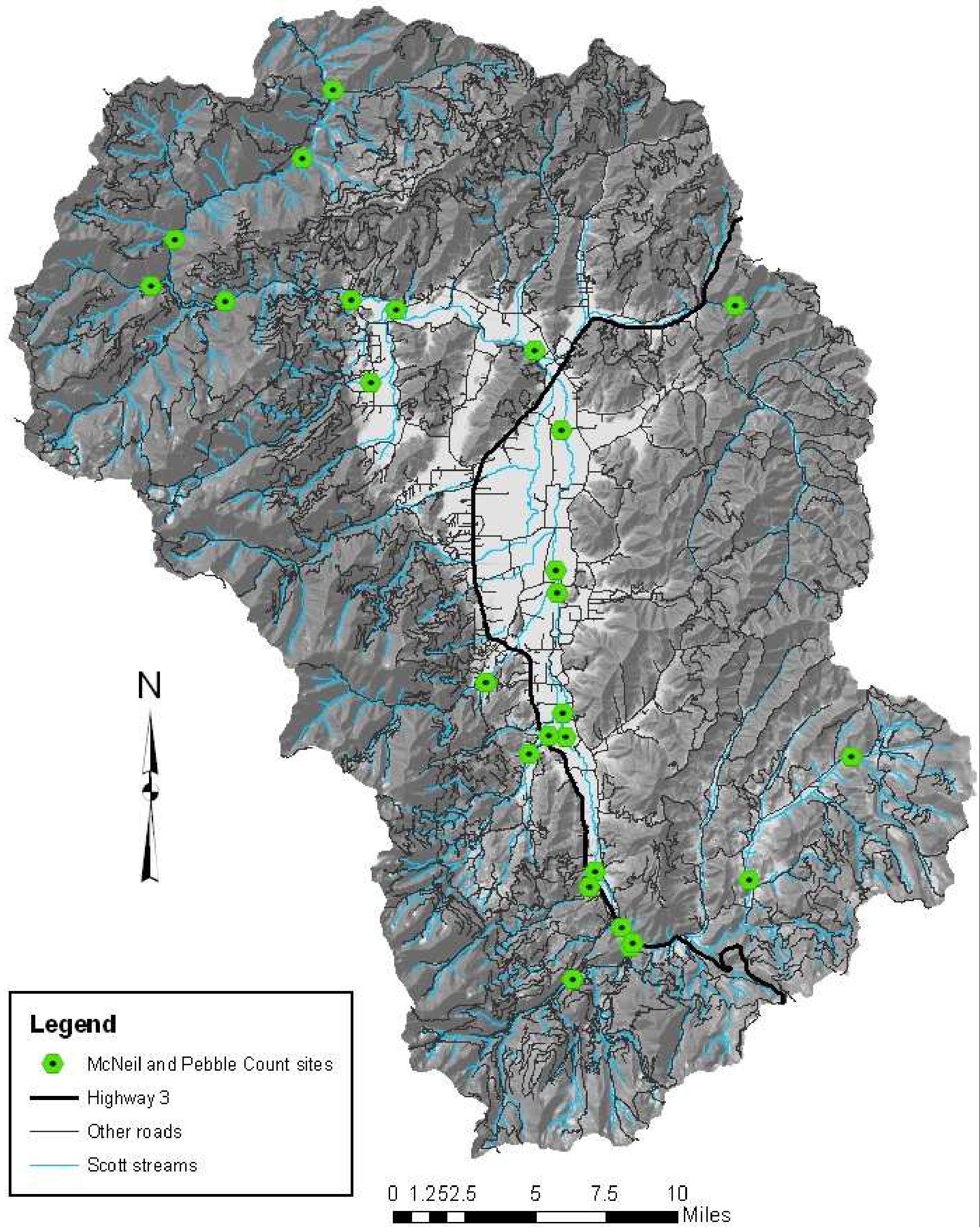
| Mainstem | River Mile | 7/3 2003 | 7/16 2003 | 7/25 2003 | 7/26 2003 | 7/28 2003 | 7/29 2003 | 7/30 2003 | 8/25 2003 | 8/26 2003 | 8/27 2003 | 8/28 2003 | 9/4 2003 | 9/9 2003 | 9/10 2003 | 9/11 2003 | 9/24 2003 | 9/25 2003 | 9/26 2003 | 10/7 2003 | 10/8 2003 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scott River at Roxbury bridge | 0.6 | | | **155** | | 139 | | **123** | | | 62 | | | | **81** | 81 | | | | 68 | |
| Scott River at Townsend gulch | 10.8 | | | **150** | | | 122 | **119** | | | *57* | | | 79 | **79** | | 81 | | | 67 | |
| Scott River u/s of Middle Creek | 13.3 | | | | | | | | | | *50* | | | | | | 67 | | | 62 | |
| Scott River at Jones beach | 18.7 | | | **98** | | | 80 | **77** | | | 34 | | | 47 | **47** | | 54 | | | **43** | 44 |
| Scott River at USGS gage, measured | 21.6 | | | | | | | | | | | | 47 | | | | | | | 48 | |
| Scott River at USGS gage, rated final | 21.6 | 302 | 154 | 135 | 141 | 121 | 110 | 107 | 42 | 43 | 41 | 39 | 46 | 48 | 48 | 48 | 52 | 52 | 52 | 56 | 58 |
| Scott River d/s of Meamber bridge | 25.1 | | | | | | | | | | 27 | | | | | | | | | | |
| Scott River u/s of Kidder | 32.5 | 193 | | **62** | | | | 49 | | | 21 | | | | 23 | | **30** | 30 | | 28 | |
| Scott River at Island Road | 35.1 | 195 | | **61** | | | | 49 | | | 21 | | | | 23 | | **30** | | | | |
| Scott River at Sweazey's Bridge | 41.8 | 179 | | **38** | | | | 30 | | | *15* | | | | 16 | | **16** | 16 | | 13 | |
| Scott River d/s of French Creek | 47.7 | 183 | | **51** | | | | 40 | | | *20* | | | | 22 | | **20** | 20 | | **11** | 12 |
| Scott River u/s of Fay lane | 50.3 | | | *32* | | | | *26* | | | **11** | 11 | | | 14 | | **13** | 13 | | 10 | |
| Scott River at Alexander's | 53.2 | 126 | | | | | | | | | | | | | | | | | | | |
| Scott River u/s of French Ck | 48.1 | **175** | 67 | **59** | | | | | | | | | | | | | | | | | |
| Scott River d/s of French Ck | 47.9 | **170** | 65 | **57** | | | | | | | | | | | | | | | | | |
| Scott River at Callahan, preliminary | 56.9 | 141 | 72 | 95 | 82 | 49 | 48 | 43 | 24 | 23 | 23 | 23 | 27 | 30 | 28 | 27 | 23.2 | 22.3 | 22.2 | | |

Bold values are based on comparison with flows at the gage.
Italic values are based on a ratio of flows at a nearby site to flows at the site measured at some other time.

Table 7: Scott River flows in 2006, measured and reported by Siskiyou RCD staff (Yokel and Yokel, 2007). Units are $ft^3/s$.

| Site | River Mile | 7/6/2006 | 7/18/2006 | 7/31/2006 | 8/14/2006 | 8/25/2006 | 9/8/2006 | 9/20/2006 | 10/4/2006 |
|---|---|---|---|---|---|---|---|---|---|
| USGS Gage | 21.6 | **289** | **174** | **64** | **42** | **31** | **40** | **56** | **64** |
| Meamber Gulch | | **283** | **132** | **68** | **36** | | **33** | **42** | **50** |
| Meamber Bridge | 25.2 | | **116** | **62** | **34** | | **24** | **34** | **40** |
| Old SVID | 31.6 | **252** | **94** | **47** | **34** | | **23** | **27** | **30** |
| Eller Lane | 39.4 | **230** | **87** | **41** | **29** | **14** | **18** | **19** | **24** |
| Above Etna | | | **65** | **24** | **20** | **13** | **11** | **14** | **19** |
| Below French | | | **77** | **45** | **31** | **18** | **16** | **13** | **16** |
| Above French | | **186** | **77** | **39** | **26** | | **11** | **10** | **15** |
| Fay Lane | 50.3 | **177** | **55** | **26** | **18** | **10** | **7.4** | **6.2** | **7** |
| Below Wildcat (Red Bridge) | 56 | | **82** | **47** | **29** | **20** | **15** | **16** | **12** |

Figure 1: Scott River Watershed Surface and Subsurface Sediment (McNeil and Pebble Count) Sampling Sites



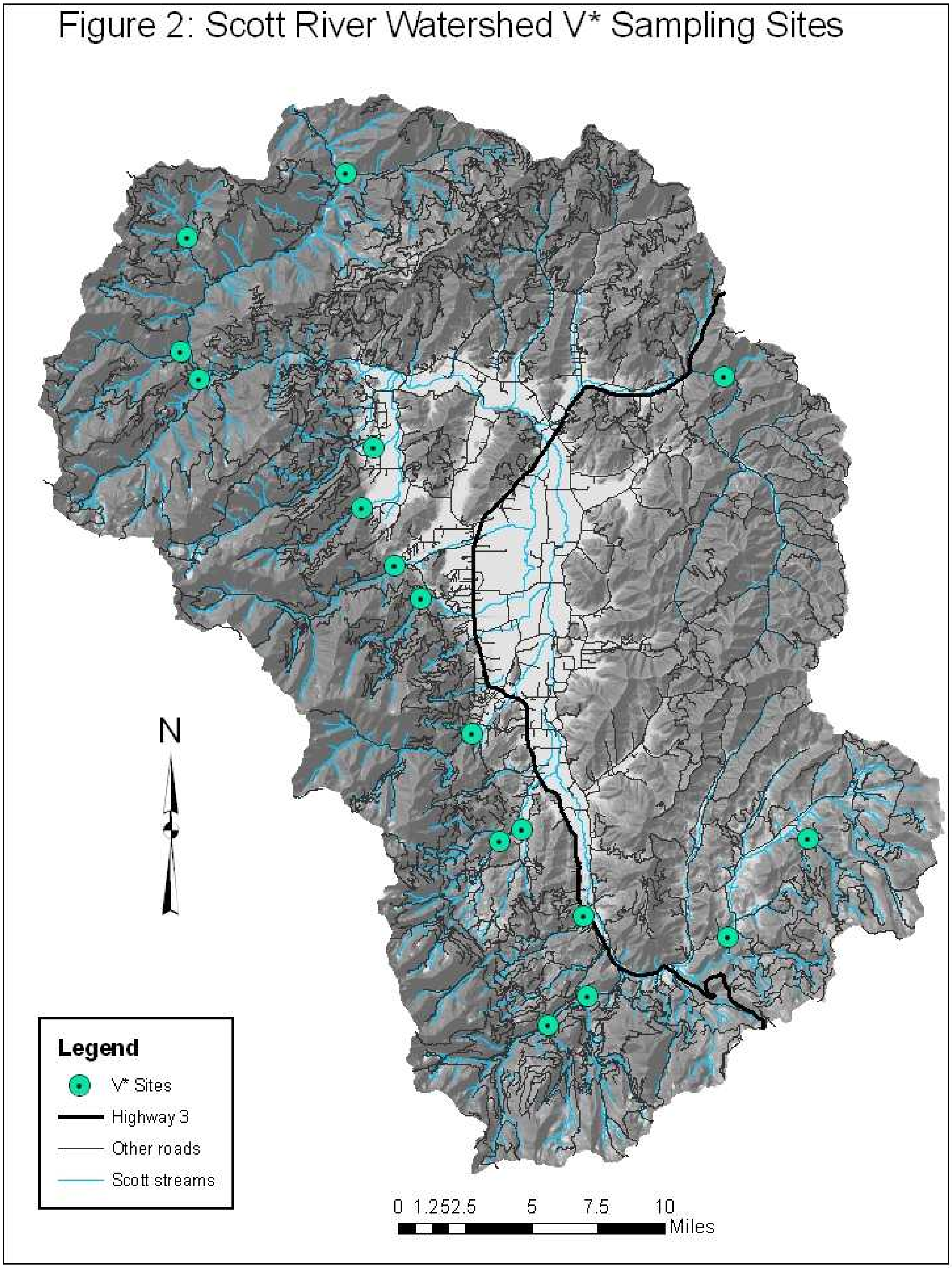


Figure 2: Scott River Watershed V* Sampling Sites
N
Legend
V* Sites
Highway 3
Other roads
Scott streams
0 1.252.5 5 7.5 10
Miles

Figure 3: Scott River Watershed Cross-Section Monitoring Sites

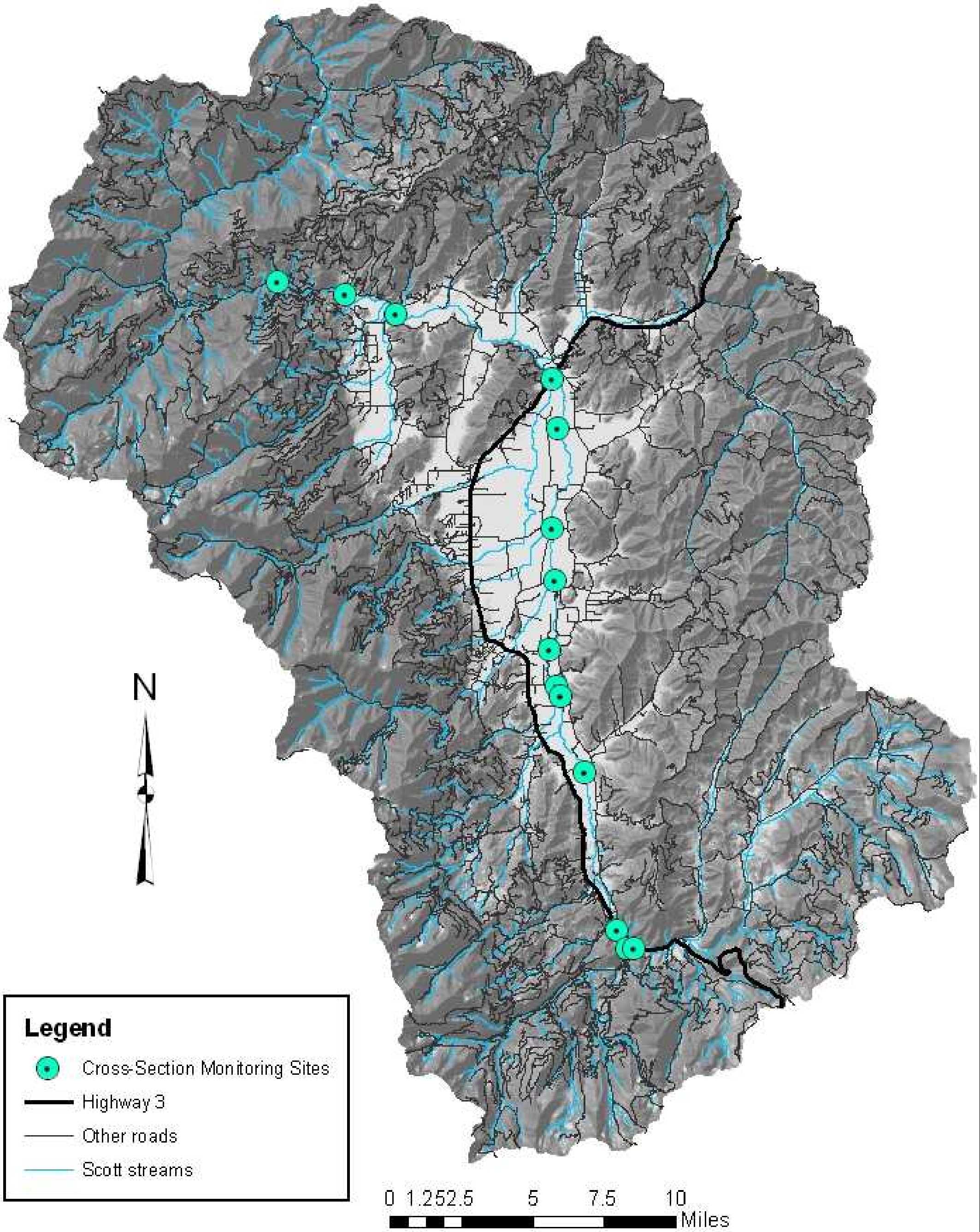


Figure 4: Scott River Watershed Temperature Monitoring Sites

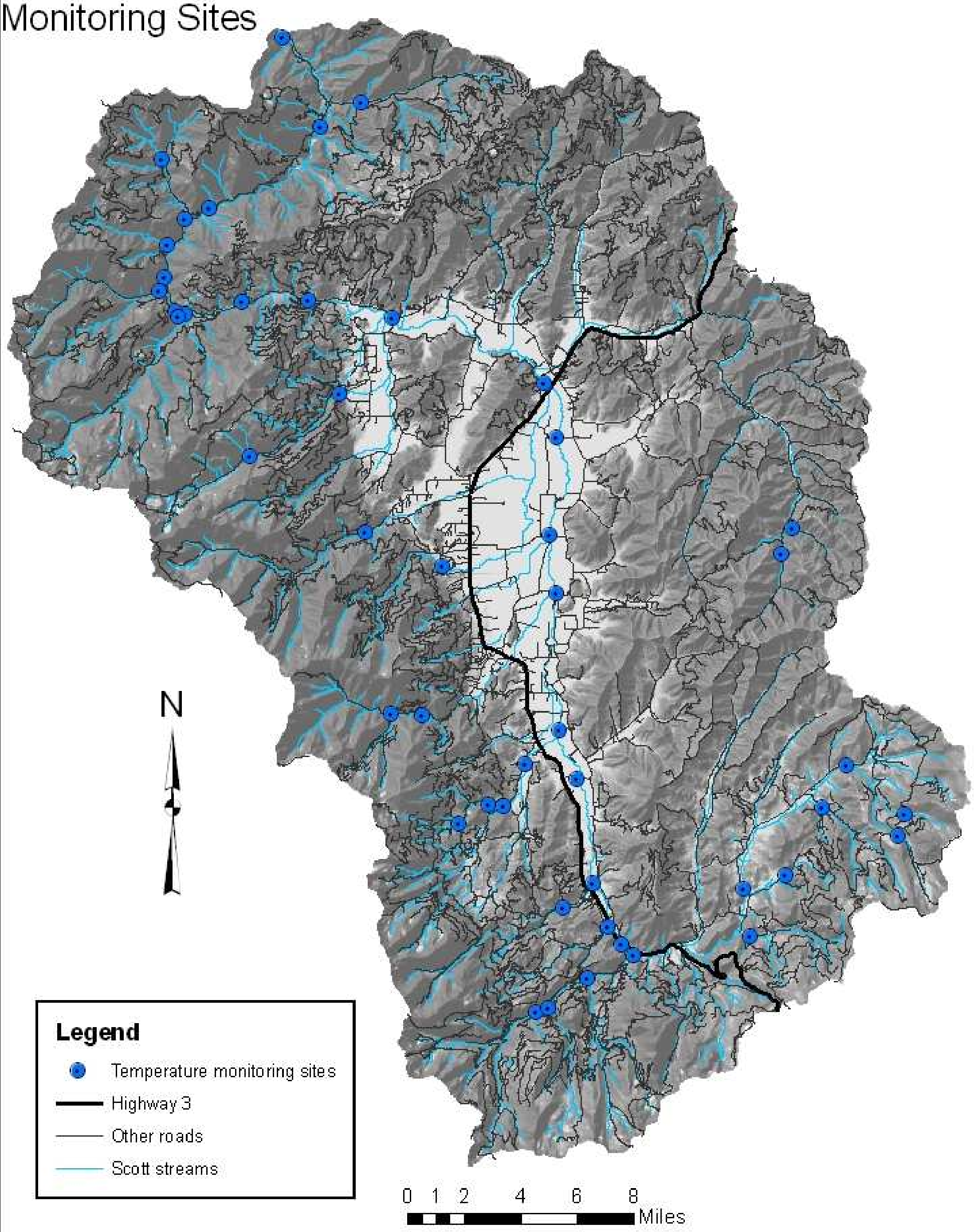


Figure 5: Adjusted Potential Effective Shade estimates, Scott River Watershed

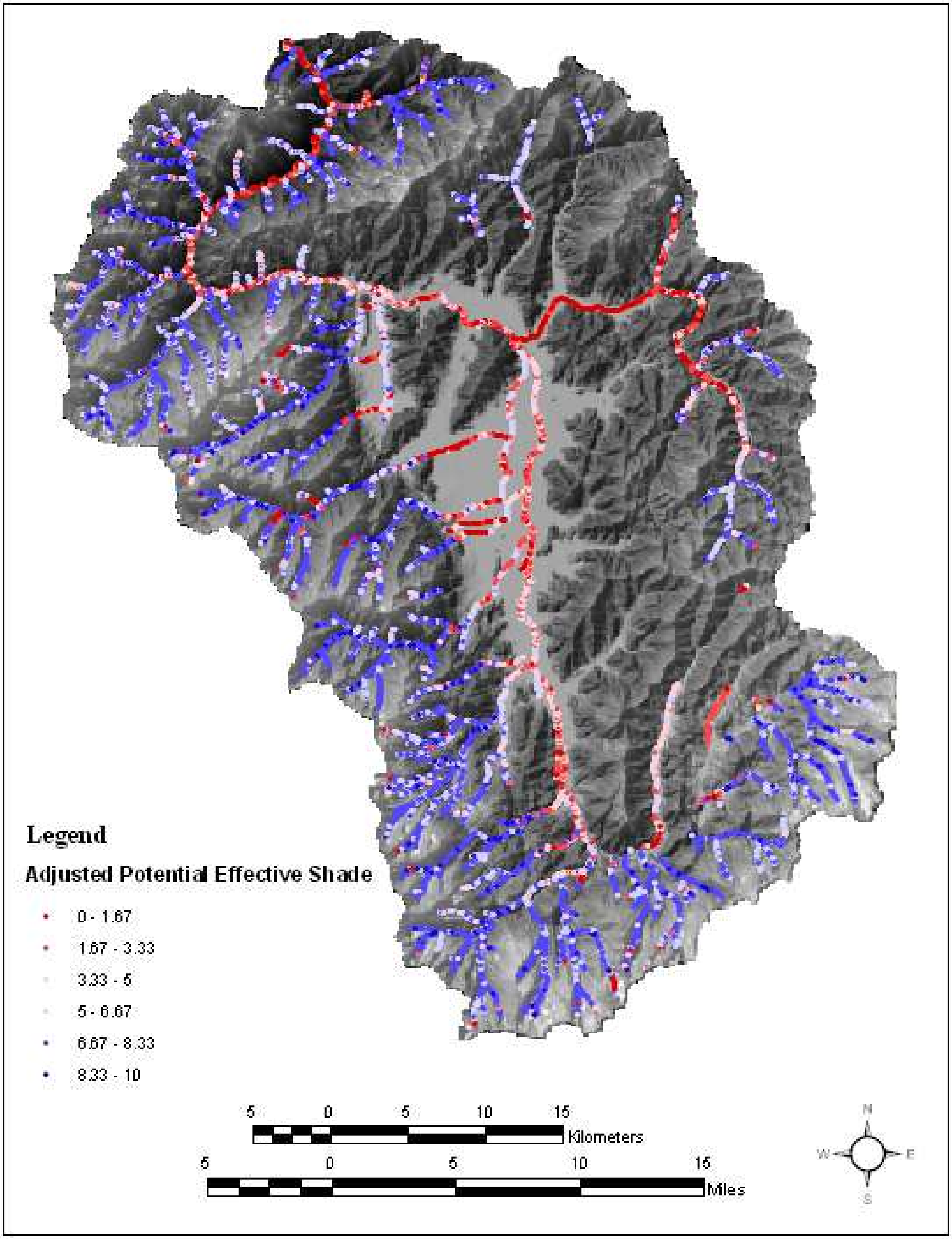


Figure 6: Effective Shade vs. Channel Width, Douglas Fir Forest (DFF) and Mixed Hardwood – Conifer Forest, Buffer Height = 40m

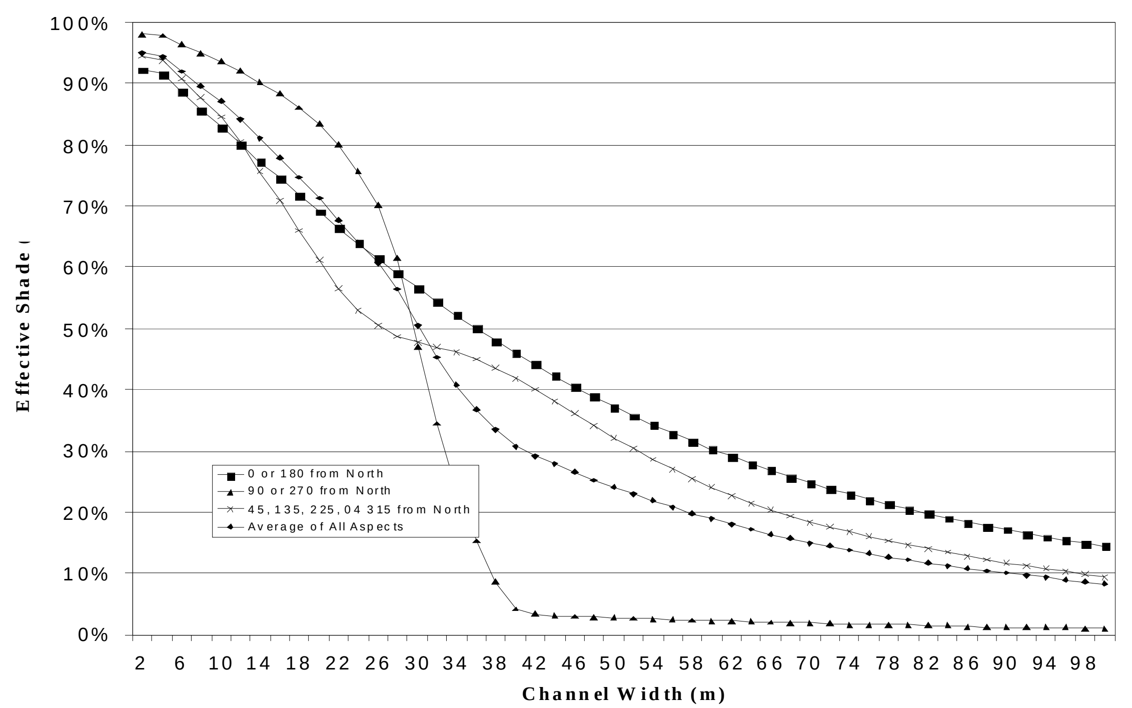



Figure 7: Effective shade vs. channel width, Klamath Mixed Conifer Forest (KMC) and Ponderosa Pine Forest (PPN), buffer height =35m

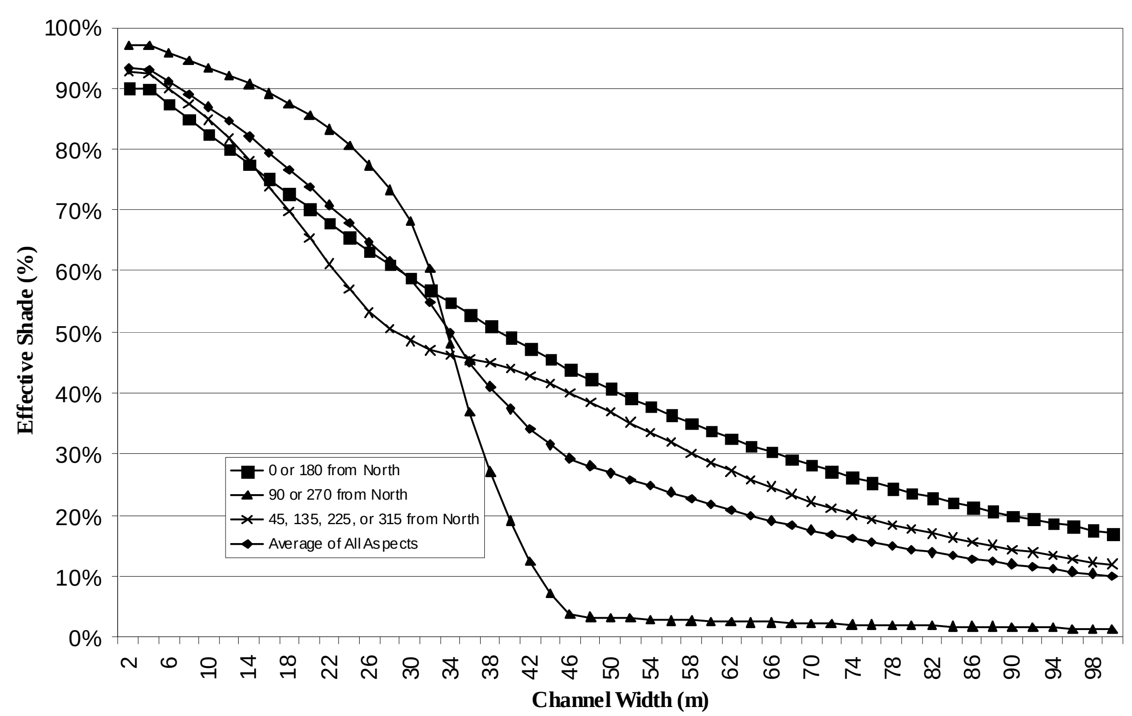
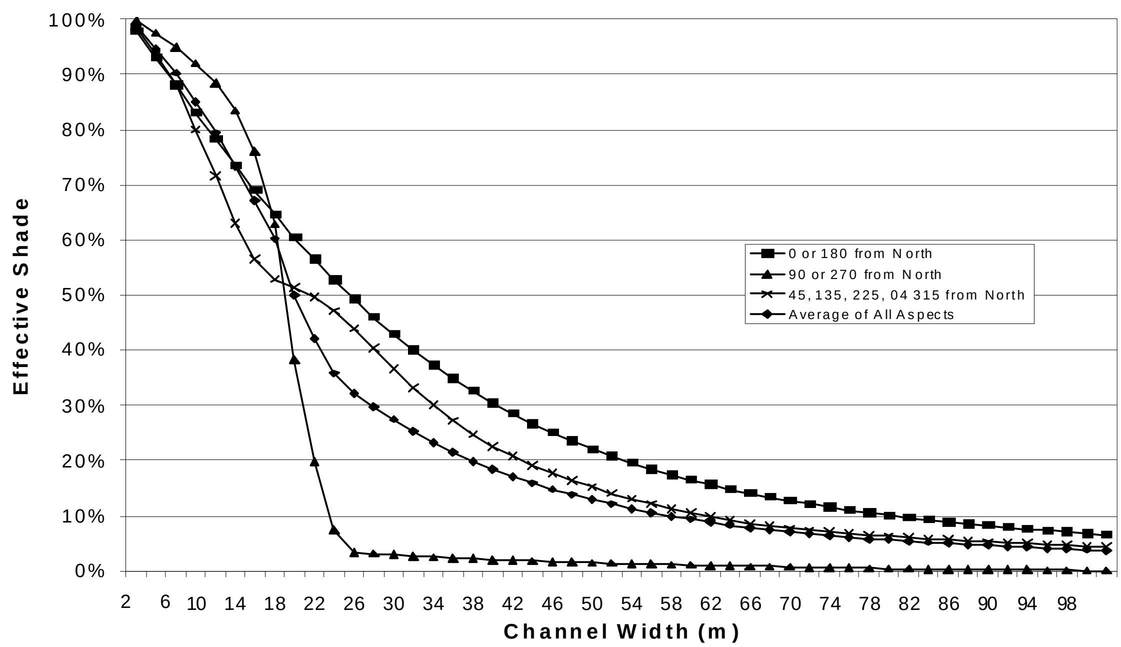


Figure 8: Effective shade vs. channel width, Oak woodland, buffer height =20m



**SOLAR PATHFINDER**
**QUALITY ASSURANCE PROJECT PLAN**

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**SOLAR PATHFINDER**
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## 1 Introduction and Problem Description

Stream temperature is affected by a variety of environmental factors including riparian vegetation, stream morphology, hydrology, climate, and geographic location. These environmental factors influence the heat transfer experienced by a stream and are associated with direct solar radiation, longwave radiation, evaporation of water from the stream surface, convection between the stream and air, and conduction between the stream and its bed. Solar radiation only delivers energy to a stream, while the other processes are capable of either delivering or removing heat from a stream. When a stream surface is exposed to midday solar radiation, large quantities of heat energy can be delivered to the stream (Beschta et al. 1987). The proportion of solar radiation intercepted by local topographic features and riparian vegetation becomes an important parameter in understanding temperature regimes in streams.

The Solar Pathfinder was developed for use in siting solar collectors or photovoltaic panels. Since its development, this tool has found application by natural resource managers and researchers in characterizing the relationships among site (streamside) conditions and solar radiation reaching a stream (Platts et al. 1987). The Solar Pathfinder integrates the effects of azimuth, topographic altitude, vegetation height and position, sunrise and sunset angle, latitude, time of year, and hour angle to estimate the amount of solar radiation reaching a point of interest (Solar Pathfinder 1995).

## 2 Data Quality Objectives and Record-Keeping

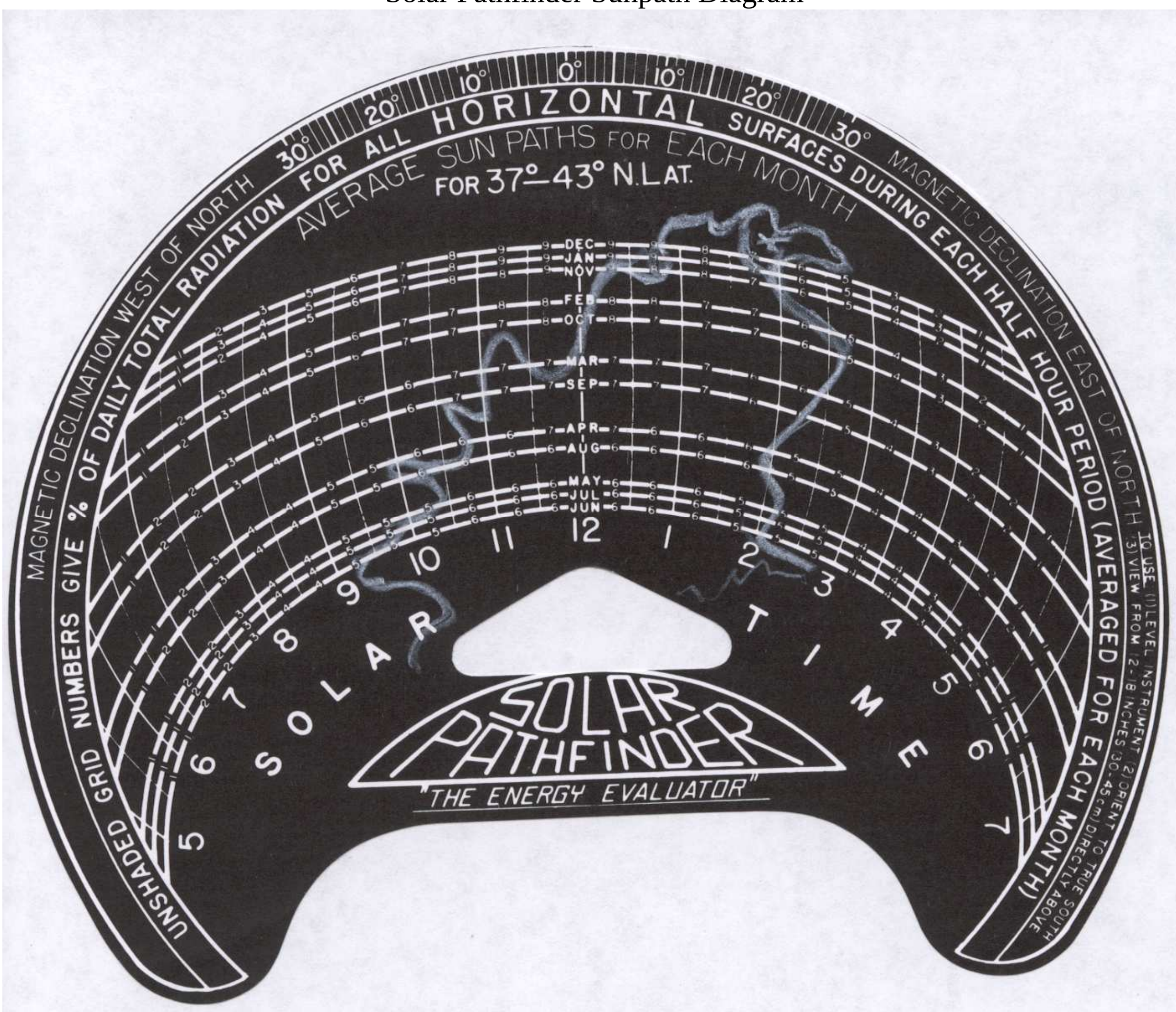
### 2.1 Data Quality Objectives for Measurement Data

In general, data quality objectives (DQOs) are used to gather data according to the procedure described herein at sites which are representative of the range of salmonid habitat conditions with particular focus on those locations where temperature has been monitored in recent years, and to record the data and site location for comparison with other data. DQOs for the Solar Pathfinder measurements are to measure riparian shade in river and stream reaches upstream and near thermal monitoring locations. A minimum of five and up to ten measurements will be collected in each upstream reach. The multiple samples will not function as replicates. Riparian conditions within a reach may vary considerably. The purpose of obtaining at least five samples from each reach is not to determine a level of accuracy, but to characterize the range of riparian shade conditions on the reach.

### 2.2 Documentation and Records

Raw data on sun and shade conditions should be recorded on sunpath diagrams provided with the Solar Pathfinder. For each location measured, a sunpath diagram (Figure 1) should be developed and retained as a permanent record of the observation. Additional data should be recorded in field notebooks at the time of measurement and should include site number, location, date, time, and environmental conditions. Sunpath diagrams and field notebooks should be retained for at least five years. All Solar Pathfinder measurements should be recorded in a database and forwarded to the Regional Water Quality Control Board and Klamath Watershed Institute.

Figure 1
Solar Pathfinder Sunpath Diagram



# 3 Measurement/Data Acquisition

## 3.1 Sampling Process Design

The primary objective of this sampling design is to develop a characterization of riparian shade at monitoring locations in the watershed, with the highest priority locations being those where related data (temperature, flow, surface particle size distribution, etc.) are measured. The total number of observations made in each reach upstream of an established monitoring location will depend on access and available time. The objective will be to define a reach of an arbitrary length estimated at 500 meters, and to measure riparian shade features at locations at 100-meter increments along this reach. This would result in six measurements for each reach.

## 3.2 Field Procedure

Much of the information in this section is derived from the Solar Pathfinder Instruction Manual (Solar Pathfinder 1995).

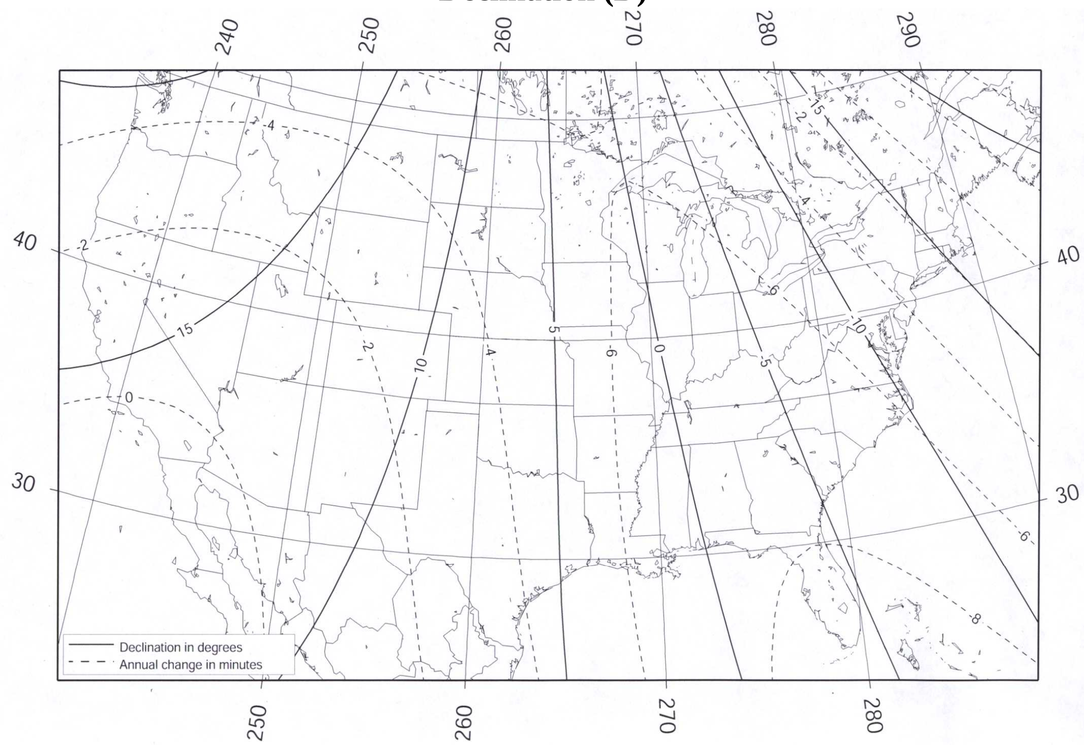
The Solar Pathfinder consists of four parts: the dome assembly, the diagram platform (containing the compass), the base, and the tripod. The following steps should be used to operate the instrument in the field.

1. Attach the base to the tripod by separating the tripod legs and inserting each rounded aluminum end into one of the rubber grommets on the base. Pull on the tripod's rubber leg ends to slide out the inside sections of the legs. Adjust the legs to approximately level the base. The base doesn't need to be precisely level, as the diagram platform and dome assembly both pivot on the base to provide additional leveling and directional orientation.

2. Put a sunpath diagram over the center pivot of the diagram platform. For stream shade measurements, use the diagrams labeled "Horizontal."

3. Orient the diagram to true south using the following directions:
   - Use the magnetic declination map (Figure 2; USGS, 1995) or declination calculator (available at http://www.ngdc.noaa.gov/geomagmodels/Declination.jsp) to find the declination for the location being measured. In Region 1, declinations vary from 16-17.5°East.

**Figure 2**
**The Magnetic Field in the United States, 1995**
**Declination (D)**




- Pull out the brass tab near the compass ¼” to unlock the center triangle and the black disk.
- Rotate the sunpath diagram on the central pivot counterclockwise for east declinations, and clockwise for west declinations, until the small white dot on the rim of the base is opposite the appropriate “Magnetic Declination East (or West)”. The declination figures are marked on the outside edge of the sunpath diagram.
- Relock the tab.

4. Set the diagram platform on the base.

5. Put the dome in place on top of the diagram platform.

6. Level the Pathfinder. Use the legs to get the Pathfinder as level as possible. Slide the instrument portion around on the cupped base until the bubble is centered in the circle.

7. Rotate the base until the south end of the compass needle is directly above the “S” on the compass. Make sure the base is still level. Make sure the compass needle is free to rotate.

8. View the Pathfinder from between 12 and 18 inches above the dome, and within ten to fifteen degrees of the vertical centerline of the sunpath diagram. Aligning the Pathfinder

vertically can be assisted by aligning the dimple on the dome with the center triangle on the base. To avoid glare from the sun, take site readings on cloudy days. On sunny days, shade the dome using your hand or orient yourself to block the sun so that you do not stare at the sun's reflection on the dome surface.

9. Using a white grease pencil, trace the shapes of the objects reflected in the dome on the sunpath diagram. To minimize movement of the diagram and dome, trace lightly, then remove the diagram and brighten the tracing. Note any features that are solely topographic in nature and any deciduous trees for use in subsequent interpretation.

### 3.3 Analytical Methods

Average percentage of monthly total radiation that will fall on the measurement location will be derived by adding the unshaded (unobstructed sky) half-hour numbers across the arc of the selected month or months, or by subtracting the shaded half-hours from 100 percent. Alternatively, average percentage of monthly shade at the location will be derived by adding the shaded (obstructed sky) half-hour numbers across the arc of the selected month or months, or by subtracting the unshaded half-hours from 100 percent. By noting those portions of the obstructed sky attributable to deciduous trees, it will be possible to account for variations in tree density associated with coniferous versus deciduous tree cover.

The results from individual samples collected on a reach will be combined into a single distribution as a means of estimating reach-average conditions. Standard deviations of the mean will also be calculated and reported.

### 3.4 Quality Control Requirements

The field technician should prepare the Solar Pathfinder for use in the field each day before leaving for the field. Preparation will consist of checking that all necessary components of the instrument are in the carrying case, and that adequate sunpath diagrams are available to complete the number of planned measurements. To provide independent observations at each measurement location, photographs can be taken to show the riparian cover condition recorded on the sunpath diagram.

### 3.5 Instrument Testing, Inspection, and Maintenance Requirements

No testing is necessary for the Solar Pathfinder. The instrument should be inspected before and after use for visible damage. It should be cleaned immediately after use.

### 3.6 Instrument Calibration and Frequency

The instrument requires calibration of pathfinder diagram declination and compass headings for each measurement. These calibration steps are included in the Field Procedure (Section 3.2). To check compass accuracy, the compass should be checked against another compass of known reliability prior to going in the field and regularly while in the field.

## 4 Data Validation and Usability

Field personnel that collect Solar Pathfinder data should discuss these requirements with data reviewers and come to consensus with them on whether to accept, reject, or qualify parts of the resulting data. Once data have been entered into a spreadsheet, the spreadsheet should be printed out and be proofread against the raw data. Errors in data entry shall be corrected. Outliers and inconsistencies will be flagged for further review and discussion. Problems with data quality will be discussed in the technical support document.

As soon as possible after data collection and interpretation, the data should be checked for accuracy and completeness. If DQOs are not met, the cause should be evaluated and a decision made about whether to discard the data or apply correction factors. The cause should be corrected by retraining or by reassessing equipment and methods. Any limitations on data use shall be detailed in the technical support document or appendices.

## 5 References

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Platts, W.S., C. Armour, G.D. Booth, M. Bryant, J.L. Bufford, P. Cuplin, S. Jensen, G.W. Lienkaemper, G.W. Minshall, S.B. Monsen, R.L. Nelson, J.R. Sedell, and J.S. Tuhy. 1987. Methods for Evaluating Riparian Habitats With Applications to Management. US Forest Service Intermountain Research Station (Ogden, UT) Publication INT-22.

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